

Development Of

Science & Technology In Islamic History

Shabeer Ahmad

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تطور العلوم العصرية والتكنولوجية في تاريخ الإسلام
(باللغة الإنجليزية)

ABOUT THE AUTHOR

Shabeer Ahmad, born in 1966, is a respected technologist by profession. He studied Avionics Engineering at University of London and he is currently an IT Consultant, having worked in Asia, Europe, Middle East and North America.

The author has written widely on various subjects in Islam, including science, economics, politics and history. The author is also a well respected speaker.

The current book started as a lecture for a radio station in London. Given the massive interest it generated, and the little information available, the author began to research more into historical developments of science in the Muslim world. The author felt that the contributions of Muslims in this area have not been widely acknowledged, and that there is a need to counter the view that Islam is incompatible with science. The current book is a culmination of his research over the years.



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Publisher's Note

Science has never been separate from Islam. Objective study of this subject will reveal that Islamic texts - Qur'an and the Sunnah, provided a tremendous boost for study of the physical world and the laws that govern it. As a result, discoveries and inventions became the hallmarks of the Islamic civilization.

Recently there has been a surge in the number of publications dealing with science and its relationship with Islam. These books have focused on the various verses on the Qur'an that point to the physical world to prove that science is compatible with Islam. However, areas that are not covered enough for the English reader are the historical development of science and technology in the Muslim world, and the factors that led to its rise and decline. The decline has been so severe, that today's Muslims are not even aware that their ancestors were the founding fathers of modern sciences. Just consider the common Arabic words used in the English language today like cotton, algebra, aorta, alcohol, chemistry, earth and alkaline. They are a living testimony to the pioneering work of the Muslims.

I am proud to introduce this inspiring book to our readers. It focuses on the strides made by the Muslims in various disciplines of science and technology from the early period of the Islamic State to its last days in the 20th century CE.

The unique aspect of this book is that it sheds light on the key factors that led to the rapid advances in science and technology. Furthermore, it also analyses the reasons why Muslim World declined in this field, and last but not least, how the Muslim World can achieve the same kind of success as we already have in the past.

Abdul Malik Mujahid

"800 years of invention and prosperity"

"...I'll end by telling a story. There was once a civilization that was the greatest in the world.

It was able to create a continental super-state that stretched from ocean to ocean, and from northern climes to tropics and deserts. Within its dominion lived hundreds of millions of people, of different creeds and ethnic origins.

One of its languages became the universal language of much of the world, the bridge between the peoples of a hundred lands. Its armies were made up of people of many nationalities, and its military protection allowed a degree of peace and prosperity that had never been known. The reach of this civilization's commerce extended from Latin America to China, and everywhere in between.

And this civilization was driven more than anything, by invention. Its architects designed buildings that defied gravity. Its mathematicians created the algebra and algorithms that would enable the building of computers, and the creation of encryption. Its doctors examined the human body, and found new cures for disease. Its astronomers looked into the heavens, named the stars, and paved the way for space travel and exploration.

Its writers created thousands of stories. Stories of courage, romance and magic. Its poets wrote of love, when others before them were too steeped in fear to think of such things.

When other nations were afraid of ideas, this civilization thrived on them, and kept them alive. When censors threatened to wipe out knowledge from past civilizations, this civilization kept the knowledge alive, and passed it on to others.

While modern Western civilization shares many of these traits, the civilization I'm talking about was the Islamic world from the year 800 to 1600, which included the Ottoman Empire and the courts of Baghdad, Damascus and Cairo, and enlightened rulers like Suleiman the Magnificent.

Although we are often unaware of our indebtedness to this other civilization, its gifts are very much a part of our heritage. The technology



industry would not exist without the contributions of Arab mathematicians. Sufi poet-philosophers like Rumi challenged our notions of self and truth. Leaders like Suleiman contributed to our notions of tolerance and civic leadership.

And perhaps we can learn a lesson from his example: It was leadership based on meritocracy, not inheritance. It was leadership that harnessed the full capabilities of a very diverse population-that included Christianity, Islamic, and Jewish traditions.

This kind of enlightened leadership - leadership that nurtured culture, sustainability, diversity and courage - led to 800 years of invention and prosperity..."

Carly Fiorina, former CEO of Hewlett-Packard, 26 September 2001.



Introduction

In the last 300 years Europe has contributed immensely to the universal knowledge of science and technology. Tribute must be paid to the countless individuals for their outstanding work. The sheer dedication and devotion to science in Europe was second to none, and the world is in debt to this enormous contribution.

The lives and the works of many European scientist's have been scrutinized and documented in the annals of history. Their staggering contribution to science can be seen from the names of laws of sciences, inventions and recent discoveries. For example, Newton's Laws are universally known, as are the words Volts and Watts, which come from the names of the great European scientists Sir Isaaq Newton, Alessandro Volta and James Watt.

It is therefore not surprising that people often view Europe as the birthplace of science and technology. The implication of this viewpoint is that modern scientific age is exclusively the endeavor of the European nations. Many books of history point to the European scientists, like Galileo and Newton, as the fathers of modern sciences, thus reinforcing the view that Europe is the birth place of science and technology.

In the absence of any historical context, the uneducated reader can be forgiven for having a narrow view that Europe is origin of science and technology. Based on an objective study of history, it can be seen that the huge strides made in Europe in science and technology did not happen in a vacuum. Europe did not suddenly wake up one day and decided to embark on a road of scientific discoveries, as is commonly portrayed. In fact, there were two enablers that thrust Europe ahead of others in science and technology in a short period of time:

- Adoption of Capitalistic ideology
- Access to 1000 years of scientific heritage

As for adoption of an ideology, Europeans divorced Christianity from the state, and adopted Capitalism¹ as an ideology. This led to a unified

1. Capitalism is not only a definition of an economic system based on the free market principles, but it is also used as definition of a way of life where religion is separated from the running of the state and man becomes sovereign i.e. man has the right to legislate. In this way of life, capitalistic economic system is the most prominent system in society.

vision of life, liberation in thinking, adoption of common framework for solving problems, accountability and guaranteed rights for individuals.

Furthermore, Europe had access to a millennium of rich scientific heritage. This proved invaluable for kick starting the industrial revolution, thus it became the bedrock on which Europe took the leadership in the field of science and technology.

Whose millennium of scientific heritage did Europe use? This is the fundamental question that is never answered clearly. Much is taught in Europe about the Greeks and the Romans, and then there is a leap in history to the modern times. 1000 years of history is simply lost in the middle as though this period was insignificant to mankind. This lost history is none other than the history of Islam, in which the citizens of the Islamic State led the world in many fields of human activity. The rich scientific heritage is none other than the Islamic scientific heritage that was the product of the Islamic System. In this period of 1000 years, Islam dominated and led much of the civilized world.

No mention is made of the fact that great deal of European scientific heritage actually came from the Muslims, who not only extended Greek, Persian and India works, but they were also pioneers themselves, contributing immensely to sciences. They laid foundation of various sciences though discovering laws, establishing principles and formalizing scientific thinking. It is this treasure that the West used as a springboard, yet little credit is given to Islam and the Muslims.

Furthermore, the West has always claimed that its scientific progress was a direct result of separating religion from the practical life of the people, in other words, separating the Church from the state. It is stated that religion cannot deal with the man's affairs in the ever changing modern world, and adopting it only stifles creativity and progress in many walks of life, including science and technology.

It is a fact that throughout the history of Europe, the Church was engaged in harsh treatment of the people, especially the scientists and the thinkers who opposed the views of the Church. This stagnated scientific thought and as a result, religion was perceived as impractical, inflexible, and full of contradictions. Hence, it was found to be unsuitable for the progress of humanity.

The Europeans have indeed suffered greatly under the Church. However, can generalizations be made, based on the experience of Christianity in Europe, that progress can only be made through man-made legislations and that Divine Revelation is somewhat inadequate or defective? Can this analogy also be applied to Islam? Did Islam stifle development of science and technology? Is there a contradiction between science and Islam?

This book has two main objectives:

1. To examine the argument that there is a contradiction between science and Islam. This argument originates from European experience of Christianity but it is universally applied to include all religions nowadays.
2. To highlight some of the great contributions made by Muslims to science and technology over a period of 1000 years. This scientific heritage of the Muslims formed the basis of European scientific revolution.

The book is structured in two parts:

Part 1 deals with the first objective mentioned above. It begins by tracing the historical roots of the European argument that science and religion are contradictory. It then goes to show that there is no contradiction between scientific discovery and Islam, as Islam is a way of life and not merely a set of rules related to worships devoid of reality.

Part 2 begins by showing the motivating factors that led to advances in science and technology amongst the Muslims, and then it highlights the contributions made by the scientist to various disciplines like mathematic, chemistry and so on. A list of leading scientists of the Islamic State, from the beginning of the Islamic rule in 622 CE to its end in 1924 CE, is also presented. Lastly, the factors that led to the decline of scientific thought in the Islamic State are highlighted, and Appendix provides Arabic origins of many words used today in the English language.

Part-1



The Dark Ages in Europe

The adoption of Christianity by the Roman Empire was not based on the truthfulness of Christianity or on its ability to deal with man's problems. Rather, it was adopted by Constantine in 325 CE to simply preserve the empire by building a common mentality and loyalty among the citizens. Christianity offered blind loyalty to the secular emperors, based on the understanding that the temporal authority and the spiritual authority can harmoniously co-exist.

This understanding came from the saying attributed to Jesus,

“Render unto Caesar what is Caesar's and unto God what is God's.”

Despite this, Christianity could not preserve the empire, and the demise of the Romans bequeathed many Christian states in Europe where the Church was able to dominate.

The domination of the Church meant that all affairs of life had to conform to the dogma of the Church. This caused many problems because the Bible, which the Church used as its authoritative text, dealt with only very limited matters. It gave some specific rules related to worships and foodstuffs. It gave general moral principles for Christians and set norms for their prayers and communal worship. Unlike the legislative sources of Islam, the Bible does not give detailed guidance on economy, politics, judiciary, criminal punishments, the structure and functioning of government and so on. The Qur'an informs that the Christians and Jews had changed their books so the Bible does not represent a preserved text from the Creator to man, and it leaves a huge gap when it comes to human societal affairs. This gap was an area of constant conflict of interests between kings, feudal barons and priests. During Europe's dark ages it was the priests who dominated life and when they gave judgments even kings had to submit. Yet these judgments of priests were an arbitrary and inconsistent exercise of their authority owing to the lack of a comprehensive legislative text to base their rules upon, and this laid the seeds of direct confrontation between the society and the Church.

With the passage of time, scientific discoveries were made that were at

odds with the teachings of the Church. To preserve its authority, the Church took some harsh steps against the emergence of new ideas. Many scientists were branded as heretics, infidels and satans. In 1042 AH/ 1633 CE, Galileo was forced to renounce his belief and writings that supported the Copernican theory of heliocentrism that claimed the sun was the center of the universe. The Church adamantly maintained the flawed theory of geocentrism, which stated that the earth was the center of the universe.

Also, plenty of evidence exists indicating that tens of thousands of women, who were alleged to be witches, were burnt or drowned. The response to this oppression from the people, especially the scientists, thinkers, and the philosophers such as Voltaire and Rousseau, was equally strong. They began to highlight the contradictions of the Church and called for nothing less than the separation of the Church and the state. The struggle had begun.

Desperate measures were taken by the Church to deflect the criticism, frustration and anger that were vented by the people. These measures failed to halt the flames of change that had galvanized the masses. The Church realized that it could no longer stay in charge of the state without reforming itself. Thus, the period of Reformation commenced. However, the Reformation did not guarantee any bright future for the Church as the struggle became intensified between the 16th and the 17th century CE.

The eventual outcome of the struggle for power between the Church and the thinkers and philosophers was the separation of the Church and the state. This solution was a compromise that limited the authority of the Church to preserving the morals in society and conducting rituals, and left the administration of the worldly affairs to the state. The separation between the Church and the state through the compromise solution was completed by the 18th century CE, and formed the basis of Capitalism, marking the beginning of the Enlightenment period that sparked the industrial revolution in Europe.

It is therefore clear that Europe stagnated scientifically under the arbitrary authority of the Christian Church.



Islam as an Ideology

In order to understand the relationship between science and Islam, it is necessary first to explain Islam, as it was Islam that provided the driving force of change and research in science. It is the Islamic ideology that deserves the credit and not just the individuals only.

The word 'Islam', in Arabic, linguistically means submission. As a term, 'Islam' refers to the Message that was revealed to Muhammad (ﷺ) by Allah, the One Creator, and a 'Muslim' is the one who believes in Allah, and accepts Muhammad (ﷺ) as the last and final Prophet and Messenger of Allah. Consequently, a Muslim believes in Islam in its entirety.

In sharp contrast to Christianity and Judaism, Islam is not merely a religion. Rather, Islam is a unique and comprehensive ideology that guides the life of the human being. The Islamic ideology, by the definition of an ideology, consists of both the '*Aqeedah* (creed, doctrine) and Systems, to regulate the practical life of human beings.

The Islamic '*Aqeedah* provides the correct and comprehensive answers to the fundamental questions regarding humanity's existence and that of the universe. It addresses the issue of the human being's purpose in life, and links it with what preceded life and what will come after it, thereby settling humanity's core problem and providing the basis for systems and rules to properly Organize human affairs. This '*Aqeedah* also provides the basis for a means to implement Islam in reality, thus transferring it from 'theory' to 'practice'. This means of implementing Islam is through the State. The State is an integral part of the ideology and distinguishes it from a philosophy, which provides hypothetical ideas but no means to implement them.

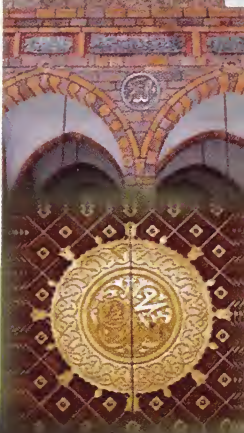
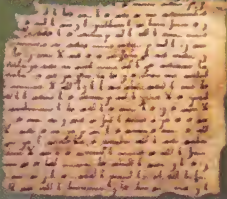
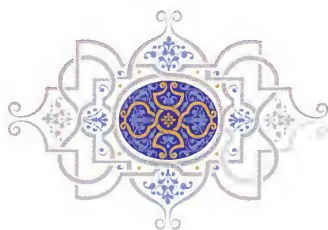
Islam provide a comprehensive structure to govern the affairs of human beings. It correctly establishes:

- 1) The relationship between the human being and his Creator
- 2) The personal affairs of individuals
- 3) The various relationships (social, political, economic, and international) that exist in the society

Thus, Islam constitutes a Creed and Systems. What distinguishes Islam from the ideologies of Capitalism and Communism is that Islam is built on the correct idea, whereas the others are founded on a shallow and unenlightened view of the life of the human being and the world in which he exists.

Because Islam establishes the correct understanding of life and places humanity in the correct context, the systems and culture emanating from the Islamic creed would correctly address the human nature and provide the correct solutions. In this context, Islam is compatible with the human being. Islam does not ignore a human being's instincts or desires, but organizes them in the proper context, including the survival instinct that prompts man to seek material progress through the acquisition of science and technology.

Islam is an ideology that was revealed to the world. The spread of Islam is neither confined to time or place, nor dependent upon science and technology. Although science and technology has changed the living conditions of the people around the globe, the needs and instincts of humanity have not changed. Therefore, Islam, which came to organize the needs and instincts through its implementation upon society, is applicable and valid for all time.



Relationship between Science and Islam

Islam is a system of life that originated from the Allah, the Creator. Allah is the One who created man, life, and the universe and subjected man to the physical laws that He imposed on the universe. The Qur'an, as revealed to Muhammad (ﷺ), directs man to think and study the physical world in order to understand the reality and to appreciate more the greatness of the Creator.

Many verses in the Qur'an point to the physical world and explain natural phenomena, as a confirmation for humanity that this revelation came from the Creator. Some of these explanations could not be understood at the time of the revelation because mankind did not have the tools that are taken for granted in modern times, such as the microscope, X-rays and so on. It is only during the last hundred years that some of these explanations became understood as a result of advances in science.

The examples in the Qur'an are many and range from the creation of the universe down to the fertilization of the egg by the sperm. It will suffice here just to quote few of these verses.

إِنَّ فِي خَلْقِ السَّمَوَاتِ وَالْأَرْضِ وَاخْتِلَافِ اللَّيْلِ وَالنَّهَارِ وَالْفُلْكِ الَّتِي تَجْرِي فِي
الْبَحْرِ بِمَا يَنْفَعُ النَّاسَ وَمَا أَنْزَلَ اللَّهُ مِنَ السَّمَاءِ مِنْ مَّاءٍ فَأَحْيَا بِهِ الْأَرْضَ بَعْدَ مَوْتِهَا
وَبَثَّ فِيهَا مِنْ كُلِّ دَابَّةٍ وَتَصْرِيفِ الرِّيْحِ وَالسَّحَابِ الْمُسَخَّرِ بَيْنَ السَّمَاءِ
وَالْأَرْضِ لَآيَاتٍ لِقَوْمٍ يَعْقِلُونَ ﴿١٦٤﴾

“Verily! In the creation of the heavens and the earth, and in the alternation of night and day, and the ships which sail through the sea with that which is of use to mankind, and the rain which Allah sends down from the sky and makes the earth alive therewith after its death, and the moving (living) creatures of all kinds that He scatters therein, and in the veering of winds and clouds which are held between the sky and the earth, are indeed proofs for people of understanding.” [Translation of the meaning of the Qur'an, 2:164]

And,

وَإِنَّ لَكُمْ فِي الْأَنْعَامِ لَعِبْرَةً تَسْقِيكُمْ مِمَّا فِي بُطُونِهِمْ مِنْ بَيْنِ فَرْثٍ وَدَمٍ لَبَنًا خَالِصًا سَائِغًا
لِلشَّارِبِينَ ﴿٦٦﴾

“Verily, in cattle there is a lesson for you. We give you to drink of what is inside their bodies, coming from a conjunction between the contents of the intestines and blood, a milk pure and pleasant for those who drink it.” [Translation of the meaning of the Qur’an, 16:66]

And,

أَلَمْ تَرَ أَنَّ اللَّهَ سَخَّرَ لَكُمْ مَّا فِي الْأَرْضِ وَالْفُلَّكَ تَجْرِي فِي الْبَحْرِ بِأَمْرِهِ وَيُمْسِكُ
السَّمَاءَ أَنْ تَقَعَ عَلَى الْأَرْضِ إِلَّا بِإِذْنِهِ إِنَّ اللَّهَ بِالنَّاسِ لَرءُوفٌ رَحِيمٌ ﴿٦٥﴾

“Do you not see that Allah has made subservient to you whatsoever is in the earth, and the ships that sail through the sea by His command? He withholds the heaven from falling on the earth except by His Leave. Verily, Allah is, for mankind, full of Kindness, Most Merciful.” [Translation of the meaning of the Qur’an, 22:65]

And,

ثُمَّ جَعَلْنَاهُ نُطْفَةً فِي قَرَارٍ مَكِينٍ ﴿١٣﴾ ثُمَّ خَلَقْنَا النُّطْفَةَ عَلَقَةً فَخَلَقْنَا الْعَلَقَةَ
مُضْغَةً فَخَلَقْنَا الْمُضْغَةَ عِظْمًا فَكَسَوْنَا الْعِظْمَ لَحْمًا ثُمَّ أَنشَأْنَاهُ خَلْقًا
آخَرَ فَتَبَارَكَ اللَّهُ أَحْسَنُ الْخَالِقِينَ ﴿١٤﴾

“Then We placed him as (a drop of) sperm in a place of rest, firmly fixed. Then we made the sperm into a thing which clings (to the womb), then of that thing We made a (fetus) lump, then We made out of that lump, bones and clothed the bones with flesh, then We developed out of it another creature. So blessed be Allah, the perfect Creator.” [Translation of the meaning of the Qur’an, 23:13-14]

Although Qur’an points to the physical world to make people think, and

it encourages people to discover physical laws, the Qur'an is not a book of science. Rather, it came to organize human relationships with the self, with other humans, with the Creator, and with the surroundings. Islamic law therefore deals with the proper use of scientific facts and not with their discovery. For example, Islam does not prevent people from designing a space craft or a laser gun, but it does lay down principles for their use.

Evidence that Islam does not interfere with scientific discovery can be seen from an incident that took place during the time of the Messenger of Allah (ﷺ), who once suggested to farmers that it might be better if they left palm date trees without cross-pollinating them as they did every year. The following year, farmers complained that the trees did not produce normal yield, so the Messenger of Allah (ﷺ) said, **“You know the affairs of your world better.”** This means that this advice was not from Islamic text; rather it was a personal opinion of the Messenger of Allah (saw) as a man. Thus, people were left to their own scientific discovery and applications.

Also, there are no records in history to show that the Islamic State, its scholars or learned people ever gave Islamic rulings on scientific matters, unlike the Church in Europe, which interfered with scientific discovery. In fact, many of the leading scientists were also Islamic scholars, and they did not see any contradiction between science and Islam. However, few scientists went beyond their subject matters and propagated incorrect ideas about Islamic belief, for which they were rebuked and corrected but not tortured or persecuted.

There is, therefore, no contradiction between Islam and science.





The Islamic State established and financed many centers of learning to encourage development of science and technology. This is Taqi al-Din's observatory, showing many talented scientists at work.

Part-2

Factors for scientific advancement in Islamic History

The notion that religion is at odds with scientific development is alien to Islam. History shows that most of the scientific developments by the Muslim and non-Muslim citizens were achieved under the rule of Islam, and not by coincidence, haphazardly or when Islam was removed from practical life.

What was the motivation of the citizens to study sciences and become the founding fathers of these disciplines? What drove the citizens of the Islamic State to excel in various scientific fields? Were these people rich who had time to study and ponder; were they looking for fame and glory or were they motivated by wealth or greed?

An objective study of history shows that the main motivating factors for scientific development came from the Islamic State's policy, and not from the individuals' initiatives alone. The Khulafa² understood that Islam had given them two main obligations:

1. To look after the affairs of the citizens
2. To provide security for citizens against external threats

As for looking after the affairs of the citizens, this is specified in what the Messenger of Allah (ﷺ) said, **“Each of you is a shepherd and each of you is responsible for his flock. The leader is a shepherd and is responsible for his flock.”** [Reported in books of Bukhari and Muslim] This narration, in addition to many other evidences from Qur'an and the Sunnah, establishes the responsibility of looking after the affairs of the people on the shoulders of the Khaleefah. Looking after the affairs of the people means that the State must provide basic needs, security and rights, and solve problems and disputes that arise in society. As the Islamic State expanded, its citizens and lands under its management became vast. This brought complex problems in relations

². Plural for Khaleefah, or Caliph in English. Khaleefah is the title for the head of the Islamic State.

to inheritance, land divisions, finances, *zakat* and booty distribution, construction, agriculture, navigation and provision of medical care. So the Khulafa' needed a systematic way to resolve these problems as part of looking after the affairs of the peoples, hence they sanctioned the development of science and technology. This is proven by what is stated by al-Khawarizmi, in his book *Al-Kitab al-Mukhtasur fi Hisab al-Jabr wa al-Muqabala*:

“That fondness for science, by which God has distinguished the Imam al-Mamun, the Commander of the Faithful...has encouraged me to compose a short work on Calculating by (the rules of) Completion and Reduction confining it to what is easiest and most useful in arithmetic, such as men constantly require in cases of inheritance, legacies, partition, law-suits, and trade, and in all their dealings with one another, or where the measuring of lands, the digging of canals, geometrical computation, and other objects of various sorts and kinds are concerned.”

As for providing security against external threats, this is achieved by preparing a powerful force to act as a deterrent against the enemies of Islam. This preparation has been made an obligation in the Qur'an,

وَأَعِدُّوا لَهُمْ مَا اسْتَطَعْتُمْ مِنْ قُوَّةٍ وَمِنْ رِبَاطِ الْخَيْلِ تُرْهِبُونَ بِهِ عَدُوَّ اللَّهِ
وَعَدُوَّكُمْ وَآخَرِينَ مِنْ دُونِهِمْ لَا تَعْلَمُونَهُمُ اللَّهُ يَعْلَمُهُمْ وَمَا تُنْفِقُوا مِنْ شَيْءٍ
فِي سَبِيلِ اللَّهِ يُوَفِّ إِلَيْكُمْ وَأَنْتُمْ لَا تَظْلُمُونَ ﴿٦٠﴾

“Against them make ready your strength to the utmost of your power, including steeds of war, to strike terror into (the hearts of) the enemies, of Allah and your enemies, and others besides, whom ye may not know, but whom Allah doth know.”
[Translation of the meaning of the Qur'an, 8:60]

Preparation here indicated material strength, so scientific knowledge was required to develop superior weapons that would deter the enemies of Islam, hence, there was a need to study and develop science and technology for the sake of security.

Additional impetus for scientific development, especially in medicine and chemistry, came from what Abu Hurayrah narrated that Messenger

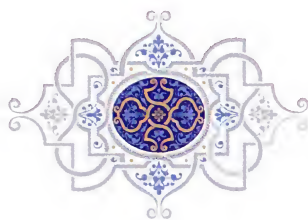
of Allah (ﷻ) said, **“There is no disease that Allah has created, except that He also has created its cure.”** [Reported in the book of Bukhari]

And, ‘Usamah ibn Shuraik narrated, **“ ‘O Allah’s Messenger! Should we seek medical treatment for our illnesses?’ He (ﷻ) replied: ‘Yes, you should seek medical treatment, because Allah, the Exalted, has let no disease exist without providing for its cure, except for one ailment, namely, old age’.”** [Reported in the book of Tirmidhi]

Thus it was clear for scientists and medical practitioners that cures were available for every disease, so they made effort in finding these cures.

It can be concluded that early Muslim and non-Muslim citizens progressed very fast in all fields of science known at the time, and pioneered into the new fields, under the supervision of the Islamic State. The Islamic State provided financial and material support for its citizens, welcomed scientists who were being persecuted by the Romans and allowed unhindered scientific research for the sake of solving practical problems. The State, therefore, created an environment in which its citizens studied, researched and developed solutions without fear or repression.

The ‘Abbasi Khulafa’ can be credited with providing the greatest push for the development of science and technology. They established centers of learning, like Bayt al-Hikmah in 832 CE in Baghdad, which was entrusted with the task of translating works from Greek and Sanskrit into Arabic. The Abbasids brought together some of finest thinkers, scholars and scientists of the time, and encouraged others to study and achieve high quality of work.





Glimpses of Scientific Achievements in Islamic History

The staggering contribution of Muslim and non-Muslim citizens to science and technology, as mentioned in this section, are meant only to serve as examples and should be understood as merely representative of the glorious services rendered by them to the overall development of universal science and technology. Although much of the earlier scientific knowledge of Muslims came from the Indians, Persians, Chinese and the Greeks, they rapidly extended this knowledge and established their own disciplines thereafter.

Before Islam, Arabs had a rudimentary knowledge of history and geography. Their history was limited to the annals of the local tribes and territories.

From the early days of Islam, the Muslims of all regions in general, and those of Arabian Peninsular in particular, traveled extensively through plains, hills, rivers, oceans, forests and deserts in connections with Jihad, Hajj and trade. In the course of their life they collected information on social, political, historical, geographical, economical, agricultural and other conditions of the land they visited or settled in.

As a consequence of the collection of such information, and the drive by the Islamic State for study and research, sciences such as history and geography became rich. During those days the travel was tedious and hazardous because there were no mechanical means of transportation, only animals, and no regular roads existed, yet the citizens traveled extensively through all kinds of terrain.

So far as the physical or experimental sciences are concerned, the pre-Islamic Arabs had some knowledge of them. With their keen sense of observation, they gathered information on animals like horses, camels and sheep and on the indigenous plants of their vast deserts. Some medical use of these plants was also known to them. The names mentioned in the pre-Islamic Arabic literature of various internal and external organs of the human and animal bodies suggest that their knowledge of anatomy was quite fair. The Arabs had some knowledge of astronomy and meteorology as well. They had some information on the fixed stars, the movements of the planets and the patterns of weather. A

number of arts and crafts such as horse breeding and camel rearing were also in existence among them.

In order to make the foreign scientific works easily understandable, it was necessary to undertake the selective translations of these scientific works into Arabic. Arabic, being a flexible and rich language, easily provided sufficient terminology for the new sciences. The objective was not just to translate but rather to build upon what was translated.

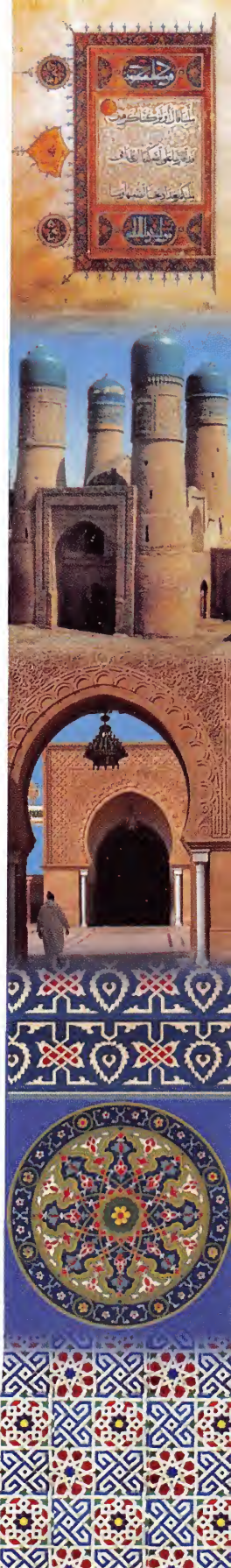
A number of academies were established in many places in the Muslim world to carry out the work of translation. During the rule of the 'Abbasi Khulafa', particularly al-Mansur (754 - 775 CE) and al-Ma'mun (813 - 833 CE), extensive activity was shown in the preparation and translation of scientific works. One such example is the establishment of Bayt al-Hikmah (House of Wisdom) in 832 CE in Baghdad, which acted as the central repository of translated work in Arabic.

Significant work was accomplished by the end of the 10th century CE. The translators belonged to different ethnic and religious groups. For instance, Nawbakht was of Persian origin. Muhammad ibn Ibrahim al-Fazari was an Arab. Hunayn ibn Ishaq was a Nestorian Christian from Hira³.

The Muslim scientists accepted the scientific conclusions of others subject to their experimental verification and also made new observations and experiments that lead to new discoveries. Muslim scientists used the practical approach to scientific problems with the abstract thought.

Muslim scientists recognized the physical or qualitative and the mathematical or quantitative aspects of science. They made qualitative as well as quantitative studies of numerous scientific problems. For instance, Ibn Khurdad-bih determined the latitudes and longitudes of various places in the Muslim world. Al-Biruni ascertained the specific gravity of a number of substances.

3. An ancient city located south of Kufah, Iraq. It was prominent in pre-Islamic Arab history.



The experiments in chemistry, physics and medicine were performed in the laboratories and those in pathology and surgery in the hospitals. Observatories were set up at various places in the Muslim world, such as Damascus, Baghdad, and Nishapur⁴ to perform astronomical observations.

Arrangements for the dissection of the corpses were made for the practical teaching of anatomy. The Khaleefah al-Mu'tasim (833 - 842 CE) supplied a physician with apes for this purpose. Practical demonstrations of surgical operations for the students were given in the hospitals.

Literacy had reached the highest standard among the Muslim people during the 11th and 12th century CE. The scientific spirit of that age is indicated by the optical work of Shihab al-Din al-Qarafi, a scholar of *fiqh* and judge of Cairo, which dealt with fifty optical problems.

In Islamic State, scientists not only made original contributions to science but also applied their scientific discoveries in technological innovation. They observed the stars, and prepared star maps for navigational purposes. Ibn Yunus made use of pendulum for the measurement of time. Ibn Sina used air thermometers to measure air temperature. Paper, compass, gun, gunpowder, inorganic acids and alkaline bases are some of the most important examples of scientific and technological developments of Muslim scientists, which brought about an unprecedented revolution in human civilization.

Muslim scientists made algebra a permanent branch of mathematics. The word 'algebra' is derived from its original Arabic root *jabr*. Muslim scientists also evolved plane and spherical trigonometry, and applied it to astronomy. They also separated astrology from astronomy, because a belief in the influence of stars on the fate of human beings is heresy in Islam. Astronomy was thus developed to the stage of a pure science after its purification from superstitious beliefs.

The numerous Arabic words and scientific terms currently being used in European languages are living monuments of Muslim contributions to modern science. In addition, the large number of books in the libraries of Asia and Europe, the museums of many countries, and the mosques and palaces built centuries ago also bear an eloquent testimony to this

4. A city in the Razavi Khorasan province in northeastern Iran.

important phenomenon of world history.

Some examples of words derived from Arabic are: cipher and chiffré (in English and French respectively), derived from the Arabic word *sifr* (meaning empty or nil), describing a number written at the right of another numeral to increase its value ten times; the word alkali in chemical terminology used for that particular substance which gives a salt when combined with an acid, is a modified form of the Arabic word *al-qali*; the French word *escadre* and the English word *squadron* for a section of armed forces, have been derived from the Arabic word *‘askariyyah* used in the same sense; and the word *admiral* is derived from *amir al-rahl* and there are many others.

In the process of translation, the names of a large number of Muslim scholars have also altered, deceiving readers into thinking that they are the names of non-Muslim Europeans. Some such names are: Abu al-Qasim al-Zahrawi is known as Albucasis, Muhammad ibn Jabir ibn Sinan al-Battani is known as Albetinius and Abu ‘Ali ibn Sina is known as Avicenna.

It is quite obvious that the spirit of inquiry created in the Muslims and the scientific method of investigation that they formulated resulted in the evolution of modern science.



Mathematics

- Number Zero
- Arabic Numbers
- Algorithms
- Al-Khwarizmi's Work on Algebra
- Spherical, Analytical & Plane Trigonometry
- Determining Roots of Quadratic Equation
- Sine, Cosine Tables
- Cubic Equations
- Work of Banu Musa on Geometry



The achievements of Muslims in the field of mathematics are extremely remarkable, and they laid the foundations on which the Western mathematics developed many centuries later.

During the 11th century CE nearly all of the original and creative work was done by Muslims. Arabic became the language in which all work was written, and even non-Muslims wrote their mathematical works in Arabic.

Extending the ancient Indian numbering system, the Muslims used numbers including the zero for counting in contrast with writing the amounts in words or counting with the letters of the alphabet. Thus they made arithmetic simple and applicable to the problems of everyday life in connection with commerce and trade. The number zero holds great importance in arithmetic. Without the zero it is not possible to indicate the figure like tens, hundreds and so on.

The West learned the use of numerals from the Muslims, and naturally, called them the Arabic numerals. The diffusion of the Arabic numerals in Christian Europe was, however, slow. The Christian mathematicians either used the old Roman numerals and the abacus, or used the Arabic numerals together with their old system.

The symbols used today for numbers in the West are derived from the Arabic symbols.

It was only in the 12th century CE that after learning from the Muslims the Western scholars were able to produce some literature on the number system without columns and incorporating the zero. This system was

named algorithms (or algorism) which was derived by the Latin writers from al-Khwarizmi⁵, a distinguished Muslim mathematicians, astronomer and geographer of the 9th century CE who flourished under the Khaleefah al-Ma'mun. His full name was Abu 'Abdullah Muhammad ibn Musa al-Khwarizmi (d. 850 CE). His influence on mathematical thought exceeded that of any other writer of that period. He wrote an encyclopedic work dealing with arithmetic, geometry, music and astronomy.

Algebra was made into an exact science by the Muslims. Al-Khwarizmi named his book dealing with this subject as *Al-Kitab al-Mukhtasur fi Hisab al-Jabr wa al-Muqabala* (The Book of Restitution and Comparison). The word *jabr* means restitution. It is the adding of some thing to a given sum or multiplying it so that it becomes equal to another value. The word *muqabalah* means comparison and is applied in comparing two sides of an equation such as $A+B = C$. The word *al-jabr* (algebra) was originally used for simple operations, like additions and multiplication, but later it evolved into an entire subject. He is rightly considered the father of algebra.

The equations described by Khwarizmi were word based and he did not use any symbols in formulating the algebraic equations and their solutions, as it is common today. The following is a sample from his book *Al-Kitab al-Mukhtasur fi Hisab al-Jabr wa al-Muqabala*:

“Roots and squares are equal to numbers; 2 for instance, ‘one square, and ten roots of the same, amount to thirty-nine dirhems;’ that is to say, what must be the square which, when increased by ten of its own roots, amount to thirty-nine? The solution is this: you halve the number of the roots, which in the present instance yields five. This you multiply by itself; the product is twenty-five. Add this to thirty-nine; the sum is sixty-four. Now take the root of this, which is eight, and subtract from it half the number of the roots, which is five; the remainder is three. This is the root of the square which you sought for; the square itself is nine.”

5. A native of Khwarizm region, now called Khiva on river Amu Darya, south of the Aral Sea in what is now Uzbekistan.



In addition, the Muslims founded analytical geometry as well as plane and spherical trigonometry.

Al-Hajjaj ibn Yusuf ibn Matar, who flourished between 786 CE and 833 CE in Baghdad, was the first to translate Euclid's Elements into Arabic. This work was twice translated, first under the Khaleefah Harun al-Rasheed (786 - 809 CE) and second under his son al-Ma'mun.

Abu Sa'id al-Darir al-Jurajani (d. 845 CE), who was a Muslim astronomer and mathematician, wrote on geometrical problems.

By the end of the 10th century CE, the number of mathematicians increased immensely Abu Kamil (850 - 930 CE), who was one of the distinguished mathematicians of this period, perfected al-Khwarizmi's work on algebra. He determined and constructed both roots of quadratic equations. He made a special study of the pentagon and decagon with algebraic treatment, mentioned the multiplication and division of algebraic quantities as well, resolved systems of equations up to five unknowns. His work was studied and greatly utilized by al-Karkhi and Leonardo of Pisa.

Abu al-Wafa's contribution to the development of trigonometry is remarkable. He was the first to show the generality of the sine theorem relative to spherical triangles. He gave a new method of constructing sine tables, and calculated the value of $\sin 30^\circ$ to eight decimal places.

'Umar ibn Ibrahim al-Khayyam was one of the greatest Muslim mathematicians and astronomers of the Middle Ages. While al-Khwarizmi deals only with quadratics, al-Khayyam mostly discusses the cubic equations. He makes a remarkable classification of the equations, which are based on the complexity of the equation, i.e. on the number of different terms which they contain.

The 'Banu Musa' or 'Sons of Musa', wrote a series of important original studies. One title was done by Muhammad ibn Musa ibn Shakir, which dealt with the measurement of the sphere, trisection of the angle, and determination of two mean proportionals to form a single division between two given quantities. His interest was not limited to geometry; he also wrote works on celestial mechanics, the atom, the origin of the Earth and an essay on the Ptolemaic universe. His brother Ahmad ibn Musa ibn Shakir wrote a fundamental work on mechanics, while Al-Hasan ibn Musa ibn Shakir wrote a study of the geometrical properties of the ellipse. Al-Hasan was perhaps the most gifted geometrician of his

time. He translated the first six books of Euclid's Elements and left the rest unfinished because he was able to work out the remaining propositions himself.

Another mathematician and geographer was Al-Hasan ibn 'Ali al-Marrakushi, who flourished until 1262 CE. He wrote various works on astronomy, which was put to practical use in astronomical instruments and methods. Also, Abu al-'Abbas Ahmad ibn Muhammad ibn 'Uthman al-Azdi, a very popular Muslim writer, authored 74 works that dealt with mathematics and astronomy. One of his books, *Talkhis Amal al-Hisab* (Summary of Arithmetical Operations) was studied for at least two centuries. It was highly admired by Ibn Khaldun, and a French translation of it appeared in 1864 CE.



Physics

- Force, Motion and Light
- The Balance
- Elasticity of Air
- Steam Bath
- Science of Optics
- Research in Spherical & Parabolic Mirrors
- Research in Angles of Incidence & Reflection



Muslim scientists studied the fundamental questions of physics deeply. For example Ibn Sina made profound studies of such phenomena as force, motion, light, heat, and vacuums to name a few. A great progress was made in theoretical and applied mechanics.

The physicist and astronomer al-Khazini wrote a book on mechanics, hydrostatics and physics named *Kitab Mizan al-Hikmah* (Book of the Balance of Wisdom) which is the most remarkable medieval work on these subjects. It gives a theory of the force of the attraction of the Earth (gravity), according to which the universal force is directed towards the center of the universe. In another book on the balance al-Khazini stresses the need to remove, as far as possible, the influences of temperature variation during weighing. When al-Khazini's other studies are considered, he seems to be a precursor of Galileo.

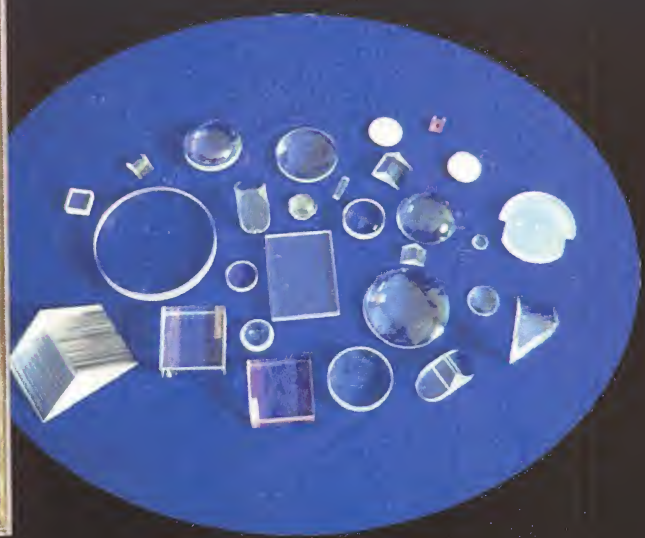
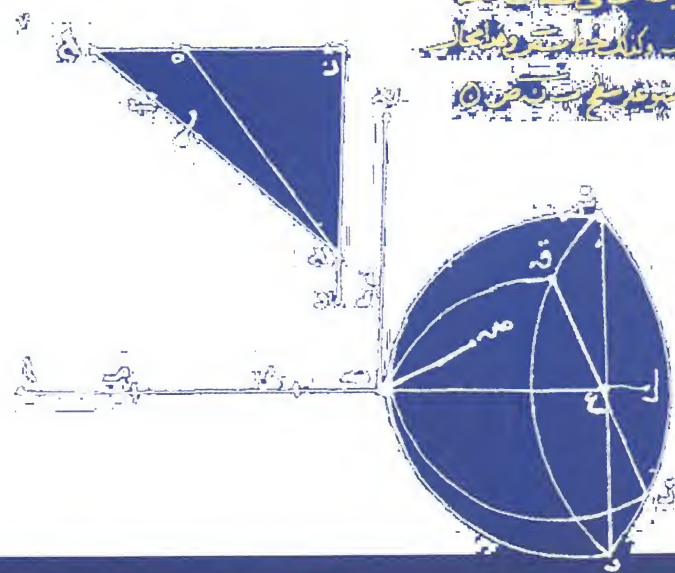
Before al-Khazini, 'Umar al-Khayyam did the greatest work on the balance. Ibn Sina and al-Razi (d. 924 CE) contributed to the theory of the balance. Al-Razi made investigations on gravity by using the hydrostatic balance, then called *Al-Mizan al-Tabi'i* (The Physical Balance).

Abu Nasr al-Farabi refuted the existence of a vacuum. He wrote a remarkable essay on the elasticity of the air. It is an original piece of research.

The Muslims developed the techniques of bathing. They constructed the hot steam bath called Hammam (from the Arabic root *hamm*, meaning to heat).

Muslims developed the science of optics. Ibn al-Haytham made a remarkable contribution towards this science. Indeed modern optics

اننا نعلم ان السطحين متساويين لان هذا السطح يقطع سطح ب
 في نقطة م و لان ب م يقطع احد خطي ب ن ب م فليكن ذلك
 الخط حصر والفضل المشترك بين هذا السطح وبين سطح قطع ق
 خط ب ن فلان هذا السطح يماس سطح م على نقطة م على خط
 ب ن ط م قطع ق م ر على نقطة م و لان خط حصر و هذا الخط
 و لان ان السطحين متساويين على خط حصر و سطح ب ن م



began with him. He showed remarkable progress in experimental techniques. He made research on spherical and parabolic mirrors and dioptrics. He noticed that the relation between the angles of incidence and reflection does not remain constant. He gave a better description of the eye and vision. He tried to explain binocular vision, and gave a correct explanation of the apparent increase in the size of the sun and the moon near the horizon. Ibn Sina made a deep study of light. He observed that if light is emitted due to the ejection of some sort of particles by the luminous source, the speed of light must be finite. Al-Biruni noticed that the speed of light is immensely greater than that of the sound.



Engineering

- **Windmills**
- **Axle**
- **Crankshaft**
- **Waterwheel**
- **Hydraulic Apparatus**
- **Magnetic Needle**
- **Dams**
- **Guns and Cannons**
- **Wind, Tidal and Steam Power**



Many centuries before the Industrial Revolution in Europe, Muslims had already started on the path of innovation in the field of engineering and industrialization. There is ample evidence that suggests that Muslims were the first to make industrial uses of tidal power, wind power and steam power.

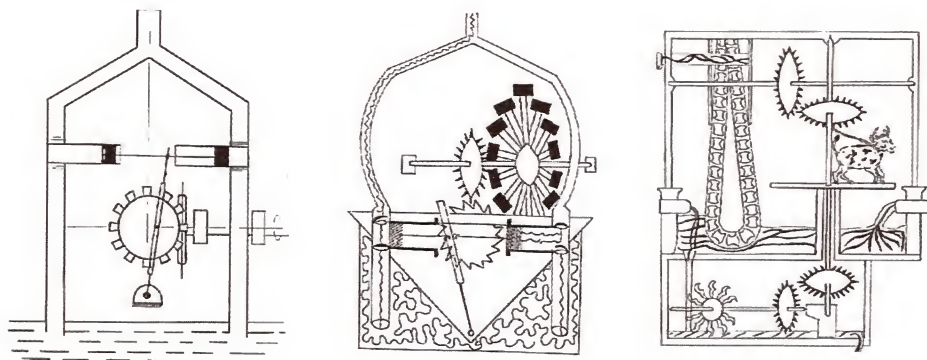
Muslims took advantage of the tide to drive machinery. The tide mill, the first machine driven by tidal power, was invented by Muslim engineers in 10th century CE in Basra. It was first described by al-Muqaddasi in 990 CE. Similar tide mills later appeared in medieval France. Building on the knowledge of the water flows, the Muslims invented water turbine, which had water wheels with curved blades onto which water flow was directed axially. This was first described in a 9th century CE Arabic text for use in a watermill.

As for wind power, the Muslims were using windmills in the 7th century CE to grind corn and to draw water for irrigation. It is reported that windmills were widely used during the rule of ‘Umar ibn al-Khattab⁶, the second Khaleefah. It was almost 500 years later that references to windmills first appeared in Europe, when France allowed its establishment in 1105 CE. By the 9th century CE, horizontal-wheeled and vertical-wheeled water mills were widely used.

6. ‘Umar ibn al-Khattab was actually killed by a Persian Zoroastrian, Abu Lulua, who was known to be a fine maker of windmills.

The Muslims are noted as the first to invent various types of industrial mills. These include fulling⁷ mills, grist⁸ mills, hullers⁹, paper mills, saw mills, ship mills, stamp mills, steel mills, sugar mills and tide mills. By 11th century CE, mills of all types were established across regions from Spain and North African to the Middle East and Asia.

In addition to the mills, many other industries were established for astronomical instruments, ceramics, chemicals, distillation technologies, clocks, glass, matting, mosaics, pulp and paper, perfumery, petroleum, pharmaceuticals, rope-making, shipping, shipbuilding, silk, textiles, weapons, and the mining of minerals such as sulfur, ammonia, lead and iron. The first large factory complexes were built for many of these industries. Knowledge of these industries was later transmitted to medieval Europe. It is reported that the first glass factories in Europe were founded in Greece in the 11th century CE by Muslim craftsmen from Egypt.

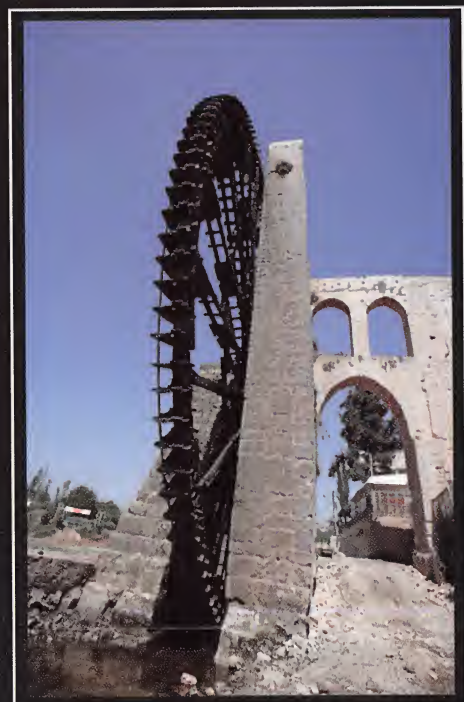


Al-Jazari's ingenious inventions of water pumping machines in 12 century CE. From left to right - Double Action Pump; Twin Cylinder Suction Pump and Waterwheel driven by animal.

7. A step in wool based cloth making which involves the cleansing of cloth (particularly wool) to get rid of oils, dirt, and other impurities, and thicken it.

8. Grist is grain that has been separated from its chaff in preparation for grinding.

9. To hull rice is to remove chaffs, the outer husks of the grain



The water wheel on the Orontes River in Syria, built in 1000 CE.

Another area of ingenuity of the Muslims can be seen in harnessing steam for power. Engineer Taqi al-Din described the first practical steam turbine as a prime mover for rotating a spit. In his book, *Al-Turuq al-Saniyya fi al-Alat al-Ruhaniyya* (The Sublime Methods of Spiritual Machines), completed in 1551 CE, he wrote:

“Part Six: Making a spit which carries meat over fire so that it will rotate by itself without the power of an animal. This was made by people in several ways, and one of these is to have at the end of the spit a wheel with vanes, and opposite the wheel place a hollow pitcher made of copper with a closed head and full of water. Let the nozzle of the pitcher be opposite the vanes of the wheel. Kindle fire under the pitcher and steam will issue from its nozzle in a restricted form and it will turn the vane wheel. When the pitcher becomes empty of water bring close to it cold water in a basin and let the nozzle of the pitcher dip into the cold water. The heat will cause all the water in the basin to be attracted into the pitcher and the [the steam] will start rotating the vane wheel again.”

The Muslims contributed greatly towards mechanical engineering as well. They worked on the mechanics of wheel, usage of axle, waterwheel, lever pulley, gears, toothed wheel, and other mechanical devices such as crank shaft.

Amongst the famous mechanical engineers of the 13th century CE was Abu al-‘Isa Ismail ibn Razzaz Badi al-Zaman al-Jazari. He wrote amply on various mechanical engineering topics and invented a number of machines. His best work was published in 1206 CE title *Al-Jami bain al-Ilm wal-Amal al-Nafi fi Sinat‘at al-Hiyal* (The Book of Knowledge of Ingenious Mechanical Devices), in which he described in great detail 50 mechanical devices. Amongst his work include water clocks, hand washing device (for making ablution), machines for raising water, double acting pumps with suction pipes, use of a crank shaft in a machine, calibration of orifices, lamination of timber to reduce warping, static balancing of wheels, use of paper models to establish a design and casting of metals in closed mould boxes with green sand. This pioneering work influenced many of European engineers for centuries to come. Al-Jazari’s magnificent work in engineering was acknowledged by the world famous Science Museum, London, in 1976 when his ‘Water Clock’ was actually constructed and the working model put on display. Al-Jazari is often considered the “father of robotics” and “father of

modern day engineering”.

Water turbines were also invented. Dams were built to regulate and channel water for usage not only in agriculture, but also to provide additional power for mills and other machines. Qaisar ibn Abu al-Qasim, a mathematician and astronomer (d. 1251 CE) made improvements on the waterwheels. Such improved types of water-wheels are still seen on Orontes¹⁰ and are among the landmarks of Hama.

Muslims led the world at that time in making clocks. Muhammad ibn ‘Ali ibn Rustam al-Khurasani was a famous constructor of clocks, and as a result, he was called *al-Sa‘ati* (the clock maker). Khaleefah Harun al-Rasheed presented one such water clock as gift to Emperor Charlemagne. According to the Emperor’s biographer, it was,

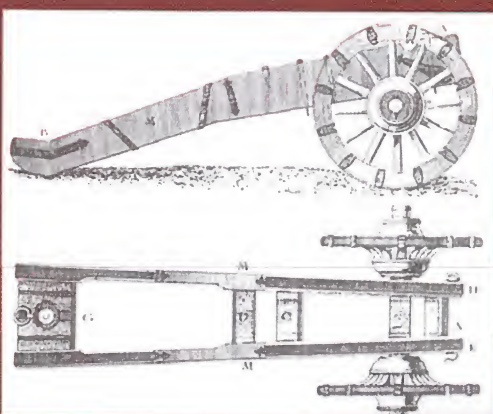
“...a marvelous mechanical contraption, in which the course of the twelve hours moved according to a water clock, with as many brazen little balls, which fell down on the hour and through their fall made a cymbal ring underneath. On this clock there were also twelve horsemen who at the end of each hour stepped out of twelve window’s closing the previously open windows by their movements.”

Muslims were the first to apply the directive property of the magnetic needle in determining their direction while traveling on the sea.

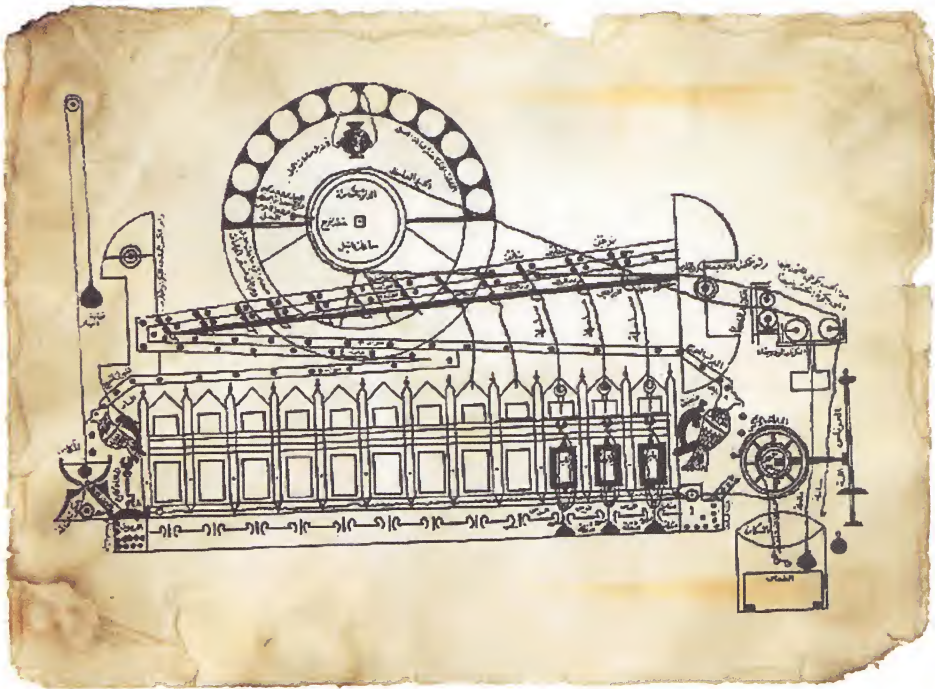
The Muslims were also the first to use explosives material in guns and cannons. The purpose of this invention was to throw bullets at the enemy from a long distance. The Chinese used sodium nitrate only. But the penetrating power of explosives was discovered and used only by the Muslims. The earliest known military applications of these explosive gunpowder compositions were the explosive cannons first used by the Muslims to repel the Mongols at the Battle of Ain Jalut in 1260 CE. The statement given by Ibn Khaldun in his *History of Berbers* also proves the use of the guns at the time of war. He writes:

“Abu Yusuf the Sultan of Morocco besieged the city of Sijilmasa in 1273 CE. He installed the instruments for besieging in front of the city. These instruments consisted of Manjneeque, Urawe and Handam with which the bits of iron were thrown. These bits were filled in the box of Handam, and the explosives kept behind them were set on fire. Its effect was powerful.”

10. The Orontes or al-‘Asi is a river of Lebanon, Syria and Turkey



Europe benefitted a great deal from the great contributions made by Muslims in the field of engineering.



Ridhwan al-Sa'ati invented the big water clock over 600 years before London's famous Big Ben was built in 1859 CE. The water clock alerted hourly beats with loud sound. The diagram first appeared in al-Sa'ati's book '*Amal al-Sa'at wal 'Amal biha*' in 1202 CE.

Architecture

- Minarets
- Domes
- Madrassa
- Gardens
- Calligraphy
- Bookbinding
- Gilding



The Muslims made advances in the area of architecture, calligraphy and visual arts related to decorations and patterns. The only areas that were omitted were that of human and animal figure paintings and statues, as they are strictly prohibited in Islam.

The main areas of development in architecture were the construction of dome based mosques with minarets, madrassas, gardens and redesign of the interior of houses to reflect an Islamic way of life.

The mosque, with its minarets, is perhaps that most famous symbol of Islamic architecture. The minaret was not used in the pre-Islamic Arab societies, nor used during the time of the Messenger of Allah (ﷺ) or the first four Khulafa'. The *muezzin* simply used the roof of the highest house to call the people for the prayer. It was recorded by Abu Dawud that 'Urwa ibn al-Zubayr narrated that one woman of Banu Najjar informed Bilal that her house was the highest, thus Bilal used to call *adhan* for *fajr* from top of her house. 'Abdul 'Aziz ibn Imran narrated that *adhan* was also made from a column in house of 'Abdullah ibn 'Umar. This column existed until tenth century hijra.

However, as the population of Madinah grew it became difficult for the *muezzin* to reach all the people from a rooftop of a house. So the need to extend the sound of the *adhan* led to the development of the minarets. Thus, in 709 CE/91 AH Khaleefah 'Umar ibn 'Abdul 'Aziz commissioned the construction of four minarets on the four corners of the Prophet's Mosque. Each minaret was about thirty feet high and with a base of 4x4 meters.

The minaret is definitely an original architectural concept introduced to the world by the Muslims. Since its early development, Muslim architects and engineers developed various materials and techniques to construct minarets across the Muslim world, allowing for local designs

to blend gracefully with the environments.

The dome is also an area where Muslims made original contributions. Although the concept of the dome existed before Islam, it is in the architectural design and construction of the dome that Muslims contributed towards. An example of one such contribution is the construction of Star Ribbed domes where a set of parallel arches is used to support the dome. These arches are rotated, and are offset from the center so that the apex does not become the main join. The rotated parallel arches provide visual elegance and serve to load balance the weight of the dome.

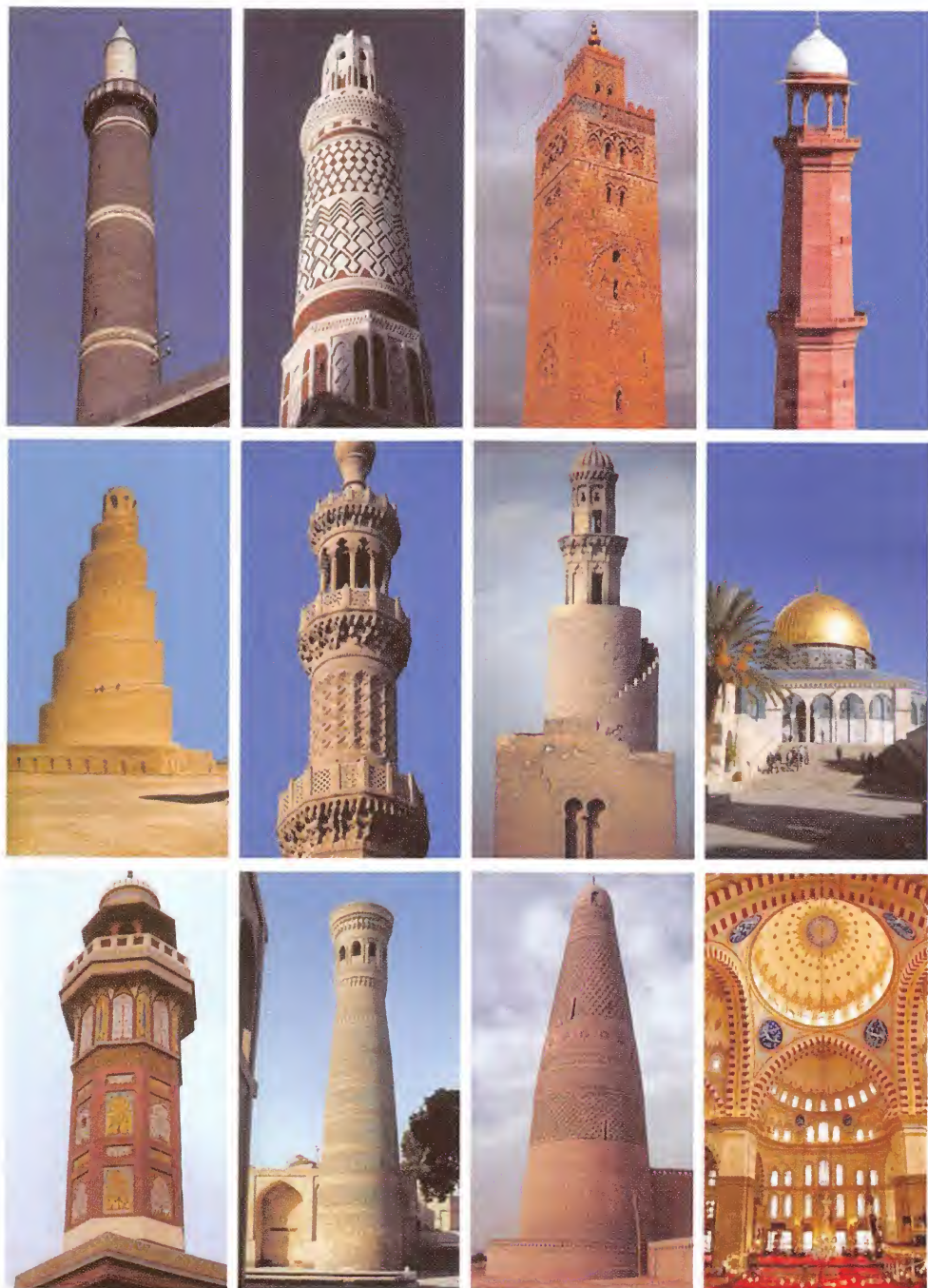
The Star Ribbed dome was first introduced in Spain with the building of the dome on the Great Mosque of Cordoba in 784 CE, where four parallel arches were used that resulted in eight-pointed star designs. This design became very popular with Muslim architects as it provided balanced proportions and stunning appearances.

Later on, twelve-sided and sixteen-sided stars were also used. The number of rotations increased over time and produced domes with twenty four, thirty two, forty eight, and sixty four rotations.

The contribution of Muslims to the design and construction of the domes influenced European architects and engineers. The examples of this are



The Star Ribbed dome of the Great Mosque in Cordoba, Spain, built in 784 CE.



The magnificent minarets from across the Muslim world. Minarets were uniquely designed to blend in with the local architecture.

Burgos Cathedral in Spain and Prague Cathedral in Czech Republic. It is reported that Leonardo de Vinci (1452 - 1519 CE) and Guarino Guarini (1624 - 1683 CE), the famous European architects, derived much inspiration from the works of Muslims.

The Muslims also developed the madrassa concept that perhaps became a blueprint for many educational institutes like the modern day college and the university. The madrassas were designed to be self-contained; meaning that they were architected to house classrooms, rest areas, prayer area and sometime a courtyard. Later on, living quarters were added for students who came from far lands.

Muslims were pioneers in the field of education, and they started to establish education institutes in the very early period of Islam. The Guinness Book of World Records considers the University of Al-Karaouine, established in 859 CE in Fez, Morocco, as the oldest continuously operating institution of higher learning in the world.

The Muslims took exceptional interest in the architecture and landscaping of the public gardens. Dated across many parts of the Muslims world from Spain to India, there are fabulous gardens that were once a joy to visit, rest and play. The gardens created by the Muslims were far more advanced than that of the Europeans and the original styles developed by Muslims would later influence the gardening styles of the Europeans. Amongst the garden architecture ideas used by the Muslims were water canals, gushing fountains, shade from trees and pavilions, abundance of fruit trees, trees planted in straight rows and clusters of colorful flowers. The unique gardening architecture provided a place of tranquility, meditation, reflection, and prayer.

The innovations in architecture were also extended to the home. Islamic way of life stipulated that privacy of the individual is of paramount importance, thus, the home became the focus for design innovations. A typical Muslim house was built on a rectangular shape with a central courtyard, and with external high walls. Normally there were no windows on external walls; if there existed, they were situated high so that passers by cannot see inside of the house. This reflected the importance of the interior space was important, not the outside. The interior were also designed to keep male and female guests separate as free social mixing between non-related people is not allowed. Thus, there were separate quarters for men and women.



The Muslims took great care in writing the words of the Qur'an, the last revelation to mankind. These are some of the beautiful examples of the calligraphy of the Muslim world.

Another interesting fact to note is that the Islamic governments constructed rest areas along the main travel routes. This was in line with the duty of the Islamic government to look after its citizens. The architecture of these rest areas reflected the needs of the travelers; they consisted of rooms for sleeping and shelter, water supply, a mosque and other essential requirements for travelers. Remains of these rest areas are found even today all over the Muslims world.

Calligraphy has always been very special for the Muslims. This is due to the fact that the Qur'an has been revealed as a book, thus it was written for its preservation, and for the subsequent transmission of the Qur'an and the *hadith* to the world beyond the Arabian peninsular. The Muslims displayed great deal of ingenuity in the science of calligraphy, often extending the work from paper to stone, wood and metal. Muslims also played a significant role in the development of bookbinding, and they excelled in the art of gilding (the art of applying a thin layer of gold, simulated gold or other metal to a surface). This influence was extended later to development of bookbinding in Europe, where the first gilded bindings appeared mid-15th CE.





Astronomy

- Need for Astronomical Science
- Travel for Trade
- Find direction of Makkah
- Building Mosques
- Star Maps
- Astrolabes
- Building of Observatories
- Celestial Motions
- Geodetic Measurements
- Verification of Solar Year
- Astronomical Instruments



The Arabs took a keen interest in the study of the heavens. They developed this interest because as the dwellers of the desert who usually traveled at night in connection with trade, war and migration from one place to another, they found the direction of their journey with the help of the stars. The clear sky of the desert gave them a chance of making precise observations. Thus there was some locally acquired knowledge of the fixed stars, the movements of the planets and the changes of the weather. After the advent of Islam, the Muslims had to determine the time of the prayers and the direction of the Ka'abah. For this Muslims who once flourished in trade all over the world of launched Jihad, had to travel on the land and the sea. As an aid to travel, navigation and meteorology, a by-product of navigation, they needed star maps. The necessity of such maps also resulted in their interest in astronomy.

The regular study of astronomy and mathematics was begun at Baghdad in the second half of the 8th century CE during the time of the second 'Abbasi Khaleefah al-Mansur. The investigations on astronomy continued until the end of the 11th century CE. Nearly all of the original and creative work was done by Muslims. Astronomy reached its highest in the 13th and 14th centuries CE. In the 12th century CE, the Christians and Jews started the work of translation from Arabic into Latin and Hebrew, and began to conduct research in this field. But until the end of the 13th century CE, no mathematical and astronomical work comparable to that of the Muslims could be produced by the Christians or

Jews.

The Muslim astronomers also prepared the star maps to preserve the old astronomical knowledge and to use them as aid to travel navigation and meteorology. Astronomer Ibrahim ibn Habib al-Fazari was the first Muslim who constructed astrolabes. He composed a poem on astrology, and compiled a Zij (calendar) according to the Arab method. He also wrote on the use of astrolabes and on the armillary spheres.

During the time of Khaleefah al-Ma'mun the important work of translation of Ptolemy's Almagest from Greek into Arabic was completed. Khaleefah al-Ma'mun (786 - 833 CE) built an observatory in Baghdad in his Bayt al-Hikmah and another in the plains of Tadmor¹¹. In these observatories the fundamental elements of the Almagest like the inclination of the ecliptic, the length of the solar year, and the precession of the equinoxes were verified. Observations on the celestial motions were carried out and geodetic measurements were made.

More original and improved work was done in the second half of the 10th century CE. The elaboration of trigonometry, which was considered to be a branch of astronomy at that time, was also continued. Great attention was paid to the construction of good astronomical instruments, especially to the spherical astrolabe which was newly introduced at that time. Hamid ibn 'Ali and 'Abdullah Muhammad ibn Jabir ibn Sinan al-Battani were famous makers of astrolabes. Al-Battani is considered to be one of the greatest astronomers of Islam. He carried out astronomical observations of a wide range and with remarkable accuracy for about 41 years (871-918 CE). He determined many astronomical coefficients, like the precession $54.5''$ a year and the inclination of the ecliptic $23^{\circ} 35'$, with great accuracy. He noticed an increase of 16° in the longitude of the sun's apogee since Ptolemy's time.

11. Tadmor was a city of central Syria, located 215 km northeast of Damascus and 120 km southwest of the Euphrates.





Fine examples of astrolabes constructed by Muslims who were pioneers in the field of astronomy and navigation.



This led to the discovery of the motion of the solar episodes and of slow variation in the equation of time. Al-Battani proved the possibility of the annular eclipses of the sun. Al-Battani's astronomical work was translated into Latin and Spanish in the 12th and 13th centuries CE respectively. It exerted a great influence on the European scholars of the Middle Ages and Renaissance.

To honor the great achievements of Muslims in the field of astronomy, 24 Moon craters were named after scholars from the Islamic civilization by the International Astronomical Union in 1935, 1970 and 1976 CE.



Chemistry·

- **Definition of Organic & Inorganic Chemistry**
- **Sulfur Mercury Theory of Metals**
- **Calcination**
- **Reduction**
- **Discoveries of various Acids Sulfuric & Nitric acids**
- **Preparation of Drugs**
- **Applied Chemistry**
- **Paper**

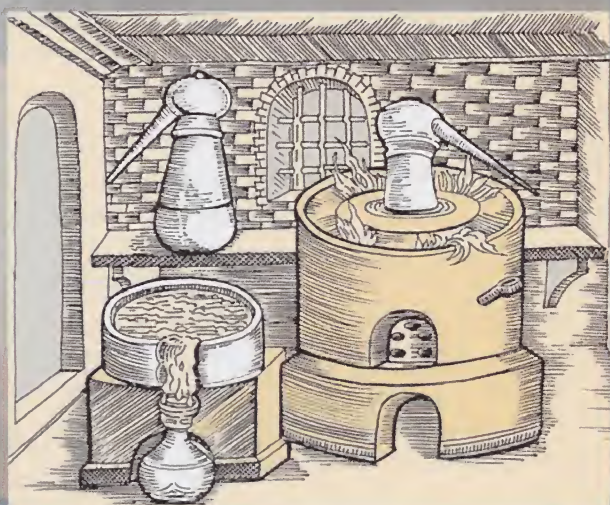


Chemistry deals with the composition and properties of substances and the changes of composition they undergo. It has been divided into Inorganic and Organic. The conception of this division in modern Chemistry came from al-Razi's classification of chemical substances into mineral, vegetable and animal.

Inorganic chemistry, which deals with the preparation and properties of the elements and their compounds, originally arose from the study of minerals and metals. Organic chemistry, which deals with carbon compounds, developed through the investigation of animal and plant products.

A Greek philosopher, Empedocles, held the view that all the four elements, air, water, earth and fire, were the primal elements, and that the various substances were made by their intermixing. He regarded them to be distinct and unchangeable. Aristotle considered these elements to be changeable, i.e. one kind of matter could be changed into another kind.

Jabir ibn Hayyan, a great Muslim chemist of the 8th century CE, modified the Aristotelian doctrine of the four elements, and presented the so called sulfur mercury theory of metals. According to this theory, metals differ essentially because of different proportions of sulfur and mercury in them. He also formulated the theory of geologic formation of metals. Unlike his Greek predecessors, he did not merely speculate, but performed experiments to reach certain conclusions. He recognized and stated the importance of experimentation in chemistry. He combined the theoretical knowledge of the Greeks and the practical knowledge of



craftsmen, and made noteworthy advances both in the theory and practice of chemistry.

Jabir's contribution to chemistry is very great. He gave a scientific description of two principle operations of chemistry. One of them is calcination which is employed in the extraction of metals from their ores. The other is reduction which is employed in numerous chemical treatments. He improved upon the methods of evaporation, melting, distillation, sublimation and crystallization. These are the fundamental methods employed in the purification of chemical substances, enabling the chemist to study their properties and uses, and to prepare them. The process of distillation is particularly used for taking extracts of plant material.

The most important discovery made by Jabir was the preparation of sulfuric acid. The importance of this discovery can be realized by the fact that in this modern age the extent of the industrial progress of a country is mostly judged by the amount of sulfuric acid used in that country. Another important acid prepared by him was nitric acid which he obtained by distilling a mixture of alum and copper sulfate. Then by dissolving ammonium chloride into this acid, he prepared aqua regia which unlike acids, could dissolve gold in it.

Jabir classified chemical substances, on the basis of some distinctive features, into bodies (gold, silver, etc.) and souls (mercury, sulfur, etc.) to make the study of their properties easier.

In the same century Jabir's work was further advanced by al-Razi who wrote many chemical treatises, and described a number of chemical instruments. He applied his chemical knowledge for medical purposes, thus laying the foundation of applied chemistry.

Abu Mansur distinguished between sodium carbonate and potassium carbonate. He had some knowledge of arsenious oxide, cupric oxide, antimony and other substances. He knew the toxicological effects of copper and lead compounds, the depilatory virtue of quicklime, the composition of plaster of Paris and its surgical use.

The great Muslim surgeon, Khalaf ibn 'Abbas al-Zahrawi wrote a great medical encyclopedia, *Al-Tasrif*, which contains interesting methods of preparing drugs by sublimation and distillation, but it's most important part is the surgical one.

Ibn Sina wrote a treatise on minerals that provided one of the main sources of geological knowledge, and chemistry in Western Europe until the Renaissance.

The Muslim chemists applied their chemical knowledge to a large number of industrial arts. One of them is mentioned here, which will enable the reader to estimate the extent of their knowledge of Applied Chemistry.

Paper is also featured in the pioneering works of the Muslims. Paper was invented by the Chinese who prepared it from the cocoon of the silk worm. Some specimens of Chinese paper dates back to the second century CE. The first manufacture of the paper outside China occurred in Samarqand¹² in 757 CE. When Samarqand was captured by the Muslims, the manufacture of paper spread all over the Muslims World. By the end of the 12th century CE, there were four hundred paper mills in Fas alone. In Spain the main center of manufacturing of paper was Shatiba which remained a Muslim city until 1239 CE. Cordova was the center of the paper business in Spain.

The Muslims developed this art. They prepared paper not only from silk, but also from cotton, rags and wood. In the middle of the 10th century CE the paper industry was introduced into Spain. In Khurasan¹³ paper was made from linen. Joseph Karabacek¹⁴, in one of his works, explains the process of making paper in minute detail, describing how the pulp is prepared to make sheets, washed and cleaned them, colored, polished and pasted. No text comparable to this in any other language exists from that time.

The preparation of pulp involves a large number of complicated chemical processes, which indicates the level of achievement in chemistry reached by Muslims.

The manufacture of writing paper in Spain is one of the most beneficial contributions of Muslim to Europe. Without paper the scale on which

12. Samarkand is the second-largest city in Uzbekistan and the capital of Samarqand Province.

13. A region which covered parts of modern day Afghanistan, Tajikistan, Iran, Uzbekistan, and Turkmenistan.

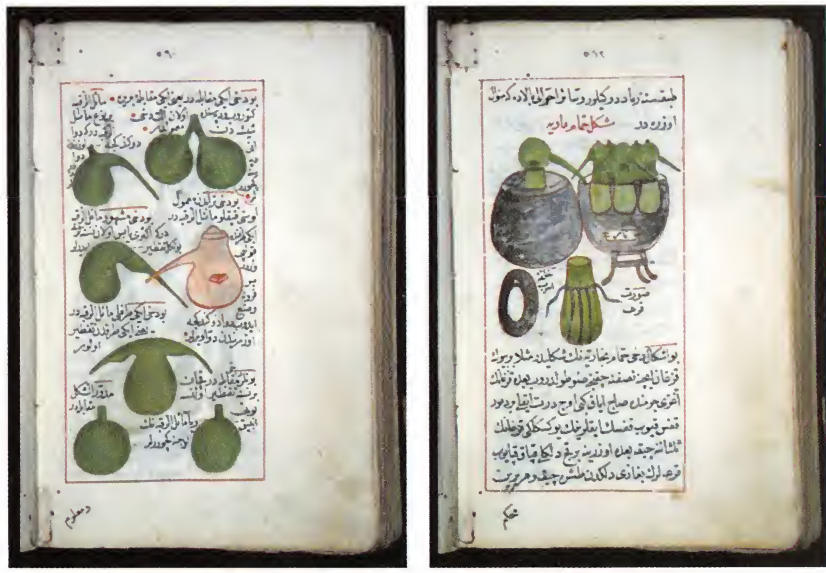
14. Joseph Karabacek, d. Vienna, 1918, orientalist, professor at the university of Vienna, 1899-1917 director of the court library, together with C. W. Huber founder of the Vienna numismatic association, leading personality in the field of Arabic papyrology.



Learning and the transmission of knowledge has always been encouraged in the Islamic history. These illustrations show a typical class and study areas.

popular education in Europe developed would not have been possible. The preparation of paper from silk would have been impossible in Europe due to the lack of silk production there.

The Muslims method of producing paper from cotton could only be useful for the Europeans. After Spain the art of paper making was established in Italy in 1268 CE. France owed its first paper mills to Muslim Spain. From these countries the industry spread throughout Europe.



Medicine

- Translation of Work from Other Languages
- Knowledge of Anatomy
- Physiology
- Bacteriology
- Surgery
- Optical Work
- Operation of Cataracts
- Structure of the Eyes
- Cesarean Operation
- Development of Hospitals
- Mobile Hospitals
- Medical Schools



Centuries before the advent of Islam the Arabs had their own system of medicine in the form of herb and shrubs which was based on Chaldean¹⁵ medicine and on their own experience. Gradually Greek medicine attracted their attention. Harith ibn Kaldah was the first to introduce Greek medicine to the Arabs. Khalid ibn Yazed ibn Mu'awiya had some Greek and Egyptian books translated into Arabic during the 'Umayyah period. But the science of medicine flourished during the time of the Abbasids.

Initially, the Muslims made arrangements for the translation of Greek, Indian, Persian and Chaldean medical works into Arabic, and thus received their knowledge of medicine from these nations. Before they accepted at face value the information they extracted, they conducted research in various branches in medicine to verify what they gathered from these texts.

In addition, they made many valuable new discoveries in medical theory and practical. By combining their discoveries, with the information they filtered from other sources they evolved an entirely new system of medicine.

¹⁵. Chaldea, 'the Chaldees' was a Hellenistic designation for a part of Babylonia, which existed in the region of modern Iraq.

The Arabs had a fair knowledge of anatomy as it is obvious from the names of the internal and external organs of the human and animal bodies found in the literature of pre-Islamic Arabia. When they became acquainted with the Greek anatomical descriptions, they made investigations on them, pointed out many errors in the work of their predecessors, and made many new discoveries in this field.

In order to verify the Greek anatomical ideas prevailing at that time, Yuhanna ibn Masawaih made dissections of apes supplied to him by the order of the 'Abbasi Khaleefah Mu'tasim Billah. After this verification he composed his work on anatomy. The works of some Muslim physicians and surgeons, like *Tashrih al-Mansuri* by Mansur ibn Muhammad, contain illustrations of human organs, which are not found in the Greek works. These illustrations also throw light on the Muslims' practical knowledge of anatomy.

In the field of physiology the work of the Muslim physicians is quite valuable. For instance, Ala al-Din Abu al-Hassan 'Ali ibn Abi Hazm al-Qarshi of Damascus explained the theory of the minor circulation of blood three centuries before William Harvey, who is credited with this discovery. Also, al-Qarshi suggested that food is fuel for the maintenance of the body's heat. Abu al-Faraj 'Ali ibn al-Hussein held that there are canals in the nerves through which sensations and movement are transmitted.

The contributions of Muslims in the field of bacteriology are quite revolutionary. According to Browne, Muslims were fully aware of the theory of germs. Ibn Sina was the first to state that bodily secretions are contaminated by foul foreign earthly bodies before getting the infection. Ibn Khatimah of the 14th century CE stated that man is surrounded by minute bodies which enter the human body and cause disease. His observation was made from the great plague that effected many parts of the world. Ibn al-Khatib (1313 - 1375 CE), a Spanish physician, wrote a treatise called *On the Plague*. His observation was:

"The existence of contagion is established by experience, investigation, the evidence of the senses and trustworthy reports. These facts constitute a sound argument. The fact of infection becomes clear to the investigator who notices how he who establishes contact with the afflicted gets the disease, whereas he who is not in contact remains safe, and how transmission is affected through garments, vessels and earrings."



Muslims not only advanced in their knowledge of human body, but they also increased the body of knowledge related to animals. This illustration shows early attempts to understand animal body.

Some Muslims also gave new suggestions regarding the treatment of diseases. Abu al-Hassan, the physician of ‘Adud al-Dawlah¹⁶ introduced the process of bleeding as a treatment of cerebral hemorrhage which is often due to blood pressure.

Al-Razi suggested nourishing food for the treatment of general weakness. The Muslim physicians were the first to use the stomach tube for the performance of gastric lavage in the case of gas poisoning. They were fully aware of the principles of opotherapy centuries before Browne Sequard, who is ascribed to discovering this method of treatment.

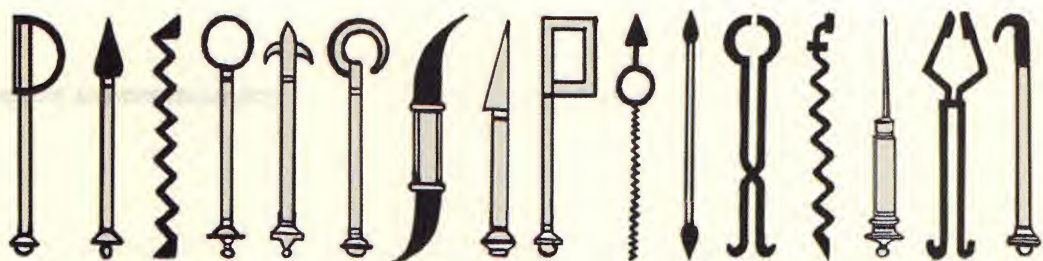
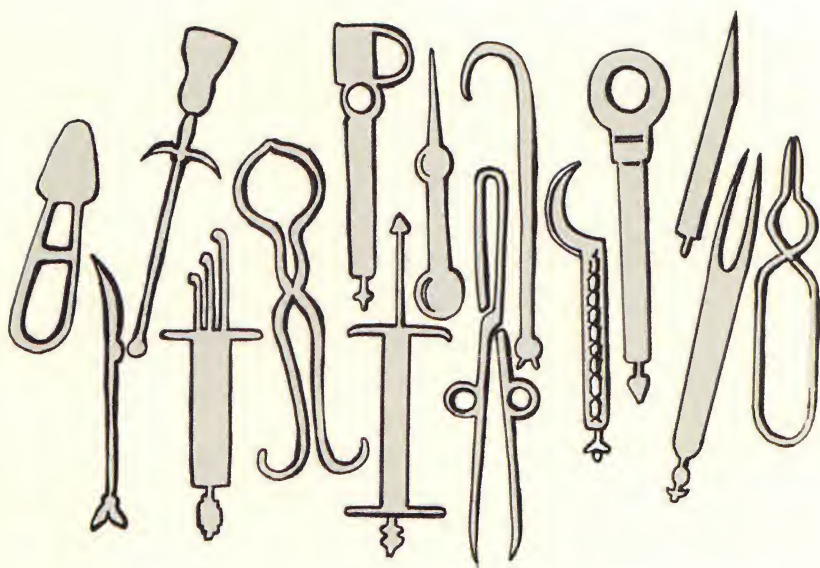
Sa‘id ibn Bishr ibn ‘Abdus suggested light foods and cold producing medicines for the treatment of general paralysis and facial paralysis. Ibn al-Wafid gave emphasis upon the treatment of diseases through food control. They discovered the treatment for epidemic jaundice and suggested a reasonable quantity of opium as a treatment of mania. For epistaxis they suggested the pouring of cold water on the head.

In the science of surgery there were also many advancements made by Muslims. They introduced the cauterizing agents in surgery. They were the first to apply the method of cooling to stop the hemorrhage, and suture wounds with silken threads.

It cannot go unnoticed that one of the most famous and eminent figure in Islamic medical field was Ibn Sina. It is said that for a thousand years he has retained his original renown as one of the greatest thinkers and medical scholars in history. His most important medical works are the *Qanun* (Canon) and a treatise on cardiac drugs.

In the 11th century CE Ibn Zuhr gave a complete description of the operation of tracheotomy, which was not mentioned by the Greeks. Abu al-Qasim al-Zahrawi invented many surgical instruments illustrated in his book *Al-Tasrif*. In the same book he described the methods of operations for various diseases. While describing the operations of the skull and its parts, the Muslim surgeons made a mention of operations of the uvula and nasal cavity. They also used methods of tonsillectomy and paracentesis of the ear drum.

16. Fana Khusrau, the son of Rukn al-Dawlah, was given the title of ‘Adud al-Dawlah by the Abbasid caliph in 948 CE when Fana was made amir of Fars (one of the regions of Iran).



Muslims invented many medical instruments and techniques. Abu al-Qasim al-Zahrawi invented the modern plaster and adhesive bandage, which are still used in hospitals throughout the world. Other inventions include catgut, forceps, cauter, ligature, cotton dressing, surgical needle, injection syringe, scalpel, curette, retractor, surgical spoon, surgical hook, surgical hook, surgical rod, and specula as well as the bone saw.

The Muslim opticians did valuable and original work in the treatment of eye diseases and surgery. Many of the surgical principles formulated by Muslims are still utilized today. The method of operation of cataracts was first described by them. They knew that cataracts were due to the incapacity of the eye lens. Ibn al-Haytham described the structure of the eye and gave revolutionary ideas regarding the mechanism of sight and describing various types of lenses.

The art of midwifery was highly developed by Muslims. Abu al-Qasim al-Zahrawi invented the method of craniotomy for the delivery of dead fetus and applied it himself. A book entitled *Al-Athar al-Baqiyyah* in the University of Edinburgh contains an illustration showing an Arab physician performing cesarean operation.

During the time of 'Umayyah rule, the Muslims developed the institution of hospitals. During the time of the 'Abbasi Khaleefah Harun al-Rasheed a hospital was built in Baghdad, which was the first in the history of this city. Many new hospitals were established shortly afterwards. Some of them had their own gardens in which the medicinal plants were cultivated. The large hospitals had medical schools attached to them. Besides such hospital there were a large number of mobile hospitals in the Muslim world.

The Muslim hospitals served as models for the hospitals established in different parts of Europe, particularly in Italy and France during the 14th century CE due to the influence of the Crusades. The Crusaders were inspired by the magnificent hospitals of the Seljuq ruler Nur al-Din in Damascus and those of the Mamluk Sultan al-Mansur Qala'un in Cairo.



Botany and Agriculture

- Names of Plants
- Method of Plantation
- Irrigation and Agricultural Methods
- Simple Drugs



There was a great scarcity of water and vegetation in the deserts of Arabia. The people living there needed plants to feed their animals. They wandered in search of vegetation, and went wherever they could find it. This great importance of plants resulted in their becoming an important topic of Arabic literature.

The study of plants was chiefly made from medical and agricultural point of view. The Arabs already knew about the medical use of some herb and shrubs. When Muslims came in contact with other people, they took interest not only in the names and uses of plants, but they also became interested in their cultivation. They sought to understand matters relating to agriculture such as the methods of plantation and fertilization, the suitable times for sowing and harvesting, and the nature of the soil. They made correct observations on sexual differences between such plants as palms and hemp. The plants were classified into those which grew from cuttings and those which grow from seeds.

The Muslims' knowledge of applied botany and agriculture can be estimated by reading the accounts of gardens and crops cultivated in different parts of the Muslim world, particularly those in Spain. At one time Muslim Spain was proverbial in this respect. The Arabs introduced irrigation and agricultural methods that transformed the region into a garden. Cotton, rice, sugar cane, asparagus, oranges, lemons and pomegranates were some of the plants and fruits brought from outside and cultivated in Spain. Throughout the countries the Europeans became aware of the cultivation of many plants which they did not know before.

The famous gardens of Persia, Spain and Morocco, with well planned arrangements of trees, shrubs and flowers, with their filled floors, their rivulets and fountains of water built with an aesthetic taste, establishing harmony between architecture and vegetation, throws light on their interest in agriculture, gardening and love for flowers.

Because the Arabs did not know much about the art of agriculture, they turned towards other peoples including the Romans, Nabateans and Persians for learning it. After they acquired this knowledge, they applied it.

In the 8th and 9th centuries CE the land of Iraq had a population of 30 million. Eighty percent of the population consisted of farmers. There were modern irrigation systems from the Tigris and Euphrates. The *kharaj* (land tax) upon irrigated land was 5% versus 10% for land not mechanically irrigated (thereby encouraging agricultural investment). The ratio of yield to seed for wheat in the Muslim world was 10 to 1 compared to 2.5 to 1 in Europe at the time of Charlemagne.

As far as plants themselves are concerned, there were many lexicographers, geographers, travelers and physicians who wrote about them. One of them was 'Abd al-Malik ibn al-Quraib al-Asmai. He was a native of Basrah, and came to Baghdad during the time of Khaleefah Harun al-Rasheed. Asmai was born in 739 or 740 CE and died in 828 CE. He is the author of a number of works on different subjects. One of them is on plants and trees. In the preface of this book the author provided a general discussion on plants. First he mentions various types of soils having different conditions regarding their capabilities for cultivation and vegetation. Then he mentions the trees, giving an account of their various stages of development. Afterwards he classifies the plants, giving examples of each class. Finally, he describes those plants which grow in plains and deserts. He mentions a total of 230 plants in his book.

Al-Biruni also made observations on plants. He discovered that flowers have 3, 4, 5, 6 or 18 petals, and never 7 or 9.

One of the most important Muslim botanists was Rashid al-Din Abu al-Fadi ibn 'Ali al-Suri. He was a great authority on simple drugs, the variety of their names, their properties and uses.

Another botanist was Abu Muhammad 'Abd Allah ibn Ahmad al-Maliki al-Nabati, known as Ibn al-Baytar. He was renowned





Large volumes of original works are still available that show enormous strides made by Muslims in botany.

for identifying the plants by name, species and the places where they grew. He traveled to Asia Minor¹⁷ and some other territories and observed the plants in the places where they grew. Ibn al-Baytar is the author of many works on simple drugs and other subjects. One of them, *Kitab al-Jami fi Adwiyyah al-Mufradah* (Book of Simple Remedies and Food), is mainly based on the works of his Greek and Muslim predecessors, but also contains his personal observations made in different lands. He gave in alphabetical order, the Persian, Latin and Berber names of the simple drugs and also cleared the confusion in the names. He also mentioned their properties and uses.



¹⁷. Asia Minor is a region of the ancient world that corresponds roughly to modern day Turkey or the peninsula of its Greek name, Anatolia.

Geography

- Reason for studying Geography
- Vastness of the State
- Prayer Direction
- Hajj
- Earth is Round
- Naval Science
- Drawing of World Map



The Muslims had to travel to distant lands across plains cities, deserts, mountains, rivers and seas during trade, military expedition and the administration of their vast state. Within one hundred years after the advent of Islam, their state stretched from Arabia to India in the East, and Morocco and Spain in the West. In the 10th century CE, the Islamic State comprised the territories of Arabia, Egypt with the entire Northern coast of Africa, nearly the whole of Spain, the islands of Sicily, Greece, some Italian towns, Syria, South East of the Caucasus, Mesopotamia¹⁸ including Iraq, the whole of Modern Persia, Afghanistan, Transoxiana¹⁹, and south west territories of India. Travels in these vast lands and their administration necessitated the accumulation of information on them.

The science of geography is somewhat related to astronomy. Therefore, the study of geography was also motivated by the same incentive as astronomy, which was the need for determination of the direction of the Ka'abah²⁰ for the orientation of the mosque and for turning faces towards it during the time of prayer.

18. Mesopotamia (from the Greek meaning 'between two rivers') was a cradle of civilization geographically located between the Tigris and Euphrates rivers, largely corresponding to modern day Iraq and western part of Iran.

19. Transoxiana is the largely obsolete name used for the portion of Central Asia corresponding approximately with modern day Uzbekistan, Tajikistan and southwest Kazakhstan.

20. The Ka'abah, located in Makkah, Saudi Arabia, is the holiest place in Islam. The *qibla*, the direction Muslims face during prayer, is the direction from their location on Earth towards the Ka'abah. It is around the Ka'abah that ritual circumambulation is performed by Muslims during the Hajj (pilgrimage) season as well as during the 'Umrah (lesser pilgrimage).

Another great factor that motivated the study of geography was the annual Hajj. Before leaving for Hajj, the pilgrims generally collected information on the territories which lay on the way to Makkah. To provide such information many itineraries were from different countries to Makkah were shown. In the early days, the information on various lands and its people was supplied mainly by the trader and travelers. In addition, Muslim traders were very active in those days. They reached as far as China, Russia, Zanjibar and the southern tip of Africa.

A large number of books on geography were produced by Muslim geographers and travelers which were widely studied. There are accounts of Ibn Batutah's travel through African jungle, Al-Bakri wrote about West Africa in 1067 CE, the *Geographical Dictionary* was compiled by Abu al-Fida and Yaqut between 1212-1229 CE and Ibn Fadlallah gives a detailed account of life in Mali in his book *Al-'Umari's Masalik al-Absar fi Mamalik al-Amsar* that was written between 1342-1349 CE. Mahmud al-Kati, a famous scholar from Africa, wrote *Kitab al-Fattash* in 1519 CE (which was complete by his son Ibn al-Mukhtar in year 1565 CE), which gives details on the Askiya dynasty of the Muslim rule of Songhay of West Africa. Also, 'Abd al-Rahman al-Sa'di wrote *Tarikh al-Sudan* in 1665 CE that provides valuable information about the region and people of Sudan.

The translations of these books were made into many European languages and for centuries the Europeans acquired the knowledge of the world through these books.

The development of naval technology was launched during the time of the second Khaleefah 'Umar ibn al-Khattab, when the Muslims started to build the navy. This navy sailed from the ports in Syria and Egypt. Mu'awiya stationed it in the sea adjacent to Cyprus until this region was opened to Islam in 649 CE. During the time of the third Khaleefah, 'Uthman ibn 'Affan, the Islamic navy defeated the Roman navy which was under the command of the emperor Constantine, son of Heraclius, in the famous battle of Umm as-Sawari (the Mother of Masts) in 654 CE.





A map of America by a Turkish Admiral Piri Reis (born 1465 or 1470 CE). His maps of the world and his book *Kitab Bahriyye* (Book of the Sea Navigation) became one of the most important representatives of marine geography of this time.

Among the well known admirals of the Islamic navy were ‘Adullah ibn Abu al-Sarh, who led the battle of Umm as-Sawari, and Ahmad ibn Deenar ibn ‘Abdullah who defeated the Roman navy in 856 CE, at the time of the ‘Abbasi Khaleefah al-Mutawakkil.

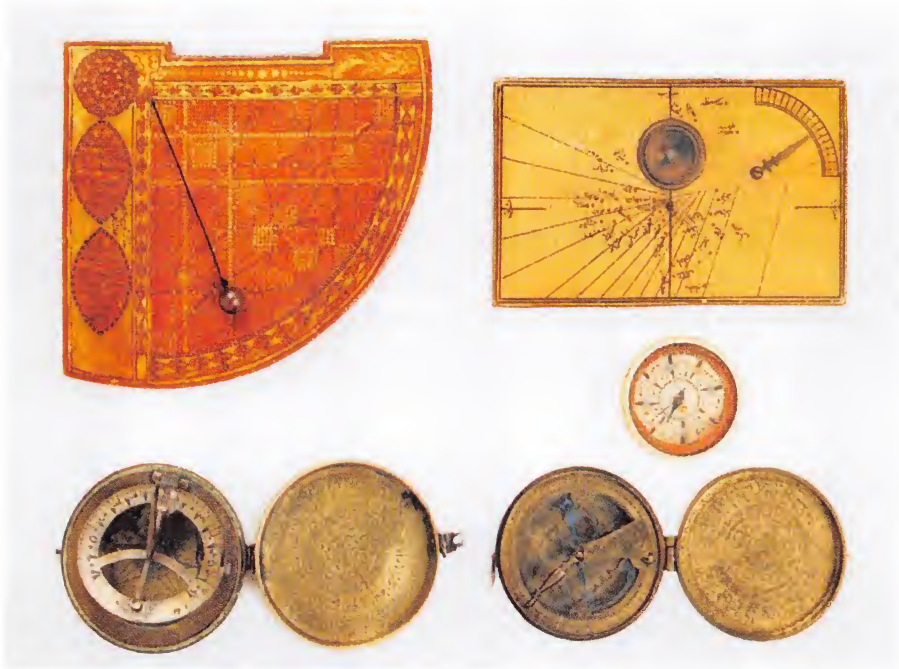
The Muslims opened up the land routes to India, China, Malaysia, and Timbuktu, the trade center of Central African trade, and sent their caravans to the rich lands beyond the Sahara long before the Portuguese reached Cape Verde in 1460 CE. They controlled the sea routes to India, and established trade points along the Eastern coast of Africa, from the Sudan Coast and Socotra to Mombassa, Mozambique, Zanzibar and Madagascar.

The seventh ‘Abbasi Khaleefah al-Ma‘mun took a keen interest in geography. He appointed seventy scholars to draw a large map of the world. One of these scholars, Ibn Musa al-Khwarizmi, compiled a geographical work called *Rasm al-Ma‘mur min al-Bilad* (Description of the Inhabited Lands) which contains the results of the research of these scholars. He made improvements on Ptolemy’s geographical work, both in the text and in the maps. He followed Ptolemy in giving the latitudes and longitudes of various places. He also gave the geographical positions of the places which originated after the rise of Islam.

The narrative of a Muslim merchant named Sulaiman who undertook travels to China and to many coast lands of the Indian Ocean appeared in 851 CE. It is the first description of these lands in the Arabic language. It throws light on the commercial relations between the Chinese and Muslims during the first half of the 10th century CE.

Another geographer, botanist, lexicographer and historian named ‘Abd Allah ibn ‘Abd al-Aziz al-Bakri wrote valuable books on many subjects. The kings of the Spanish territories used to send their books to one another as gifts. One of these books is a geographical work called *Kitab al-Masalik wa’l Mamalik*, written by al-Bakri. It is in the form of an itinerary and contains historical and ethnographic information. In addition, he also composed a geographical dictionary mainly of Arabia.

One of the travelers and geographers of the same period was Abu Hamid al-Gharnati, who was born in Granada in 1080 CE. He traveled from Spain to Sardinia and Sicily, and then to Egypt. He then went to Baghdad, Abhar and Jibal Sakhsin on the upper Volga. He also traveled to Bulgaria,



Bashgird and Hungary. He is the author of many geographical works. His descriptions of the foreign countries are largely anecdote. One of his works is entitled *Tuhfat al-Albab wa Nukhbat al-A'ja* (Gift to the hearts and choice of wonders), which provides a description of the world and its inhabitants, natural phenomena of various countries and strange geographic oddities.

Another illustrious scholar of this age and the greatest geographer of the Middle Ages was Abu 'Abd Allah Muhammad ibn Muhammad ibn 'Abd Allah, usually called al-Sharid al-Idrisi. He was also a historian, botanist, traveler, literary scholar and a poet. He was brought up at Cordova where he received his education. Then he undertook long journeys in the Mediterranean region until last he reached Sicily.

Al-Idrisi began to compile his monumental work on the world geography entitled *Kitab al-Rujari* (Roger's book) which was completed in 1154 CE. It is the most comprehensive work ever written on medieval history and geography. It is the best Arabic work on the description of Europe. The later Muslim geographers derived information on Europe from this celebrated work.

A Muslim geographer of the 13th century CE was Abu al-Hasan ‘Ali ibn Musa ibn Muhammad al-Maghribi. He was also a historian and a poet. He traveled extensively and visited Egypt, Syria and Iraq. He was the guest of Hulagu II. In 1251 CE during his stay in Baghdad ‘Ali ibn Musa visited 36 libraries in that city. He had the knowledge of the mouth of the river Senegal. He gave an account of the northern countries of Europe where white bears are found. He mentioned that Iceland is called the island of white falcons and that the true falcons are found in Denmark.



Map of the world by Ibn Hawkal (15th/16th century CE). The south is at the top.

Timeline of Scientists in Islamic History

622-632 Prophetic Period.	This period cover the time when the Messenger of Allah (ﷺ) was the ruler. He (ﷺ) had provided enormous amount of advice on health and medicine, and many excellent books are already available on Prophets' medicine, thus this area is not covered this book.
632-661 Sahabah Period	This period covers the rule of the four companions of the Messenger of Allah (ﷺ). There are no known major scientific works, although accounts are available for various technological developments, especially related to military warfare.
661-750 'Umayyah Period	This period marks the beginning of systematic development in science and technology. The 'Umayyad rulers began encouraging work in science but it is centuries before fruits of this effort are realized.
750-1517 'Abbasi Period	This period is the most significant in terms of scientific development. Most of the major achievements of Muslims came in this period as the State fully endorses scientific policy.
1517 -1924 'Uthmani Period	Although scientific development continued in the early period of 'Uthmani rule due to the momentum created in the Abbasid period, the decline sets in towards the latter half. Second half of 'Uthmani period witnesses ideological weakness, thus leading to political weakness and final abolishment of the Islamic State in 1924. Ideological weakness led to decline in science and technology.

Birth	Death	Region	Name	Field
	704	Hejaz	Khalid ibn Yazid ibn Mu'awiya	Chemistry
721	815	Iran	Jabir ibn Hayyan	Chemistry
740	828	Iraq	'Abd al-Malik ibn al-Quraib al-Asmai	Zoology, Botany, Animal Husbandry
777	857	Iran	Yuhanna ibn Masawaih (or Masawayh)	Medicine
780	850	Uzbekistan	Muhammad ibn Musa al-Khwarizmi	Mathematics, Astronomy
786	833	Iraq	Al-Hajjaj ibn Yusuf ibn Matar	Mathematics
787	886	Afghanistan	Ja'far ibn Muhammad Abu Ma'shar al-Balkhi	Astronomy
	777	Iran	Abu'l-Fadl Nawbakht	Astronomy
	777	Iraq or Iran	Abu Ishaq Ibrahim ibn Habib ibn Sulaiman ibn Samura ibn Jundab al-Fazari	Astronomy, Mathematics
	796	Iraq or Iran	Abu 'Abdullah Muhammad ibn Ibrahim al-Fazari	Astronomy, Mathematics, Translation
800	873	Iraq	Yaqub ibn Ishaq al-Kindi	Philosophy, Physics, Optics
800	873	Iran	Ja'far Muhammad ibn Musa ibn Shakir	Astronomy, Engineering, Geometry, Physics.
805	873	Iran	Ahmad ibn Musa ibn Shakir	Engineering, Mechanics
808	873	Iraq	Hunayn ibn Ishaq	Medicine, Optics, Translator
810	873	Iran	Al-Hasan ibn Musa ibn Shakir	Engineering, Geometry
	815		Yahya al-Bitriq	Poisons
828	889	Iran	Abu Hanifa Ahmed ibn Dawood al-Dinawari	Mathematics, Linguistics
836	981	Turkey	Thabit ibn Qurrah ibn Marwan	Astronomy, Mechanics
838	870	Iran	'Ali ibn Rabban al-Tabari	Medicine, Mathematics

	845	Iran	Abu Sa'id al-Darir al-Jurjani	Astronomy, Mathematics
868	929	Turkey	'Abdullah Muhammad ibn Sinan ibn Jabir al-Battani al-Harrani	Mathematics, Astronomy, Engineering
	867	Uzbekistan	Abu al-'Abbas Ahmad ibn Muhammad ibn Kathir al-Farghani	Astronomy, Civil Engineering
865	924	Iran	Abu Bakr Muhammad ibn Zakariya al-Razi	Medicine, Ophthalmology, Chemistry
870	950	Turkistan	Abu Nasr Muhammad ibn al-Farakh al-Farabi	Sociology, Logic, Science, Music
	873	Iraq	Hunayn ibn Ishaq al-'Ibadi	Medicine
850	850	Iraq	Hubaysh ibn al-Hasan al-A'sam al-Dimashqi	Ophthalmology
850	930	Egypt	Abu Kamil Shuja ibn Aslam ibn Muhammad ibn Shuja	Mathematics
892	892		Yuhanna ibn Bukhtishu'	Medicine
	990	Iran	Abu Hamid Ahmed ibn Mohammed al-Saghani al-Asturlabi	Astronomy
903	986	Iran	'Abd al-Rahman al-Sufi	Astronomy
	912	Palestine	Abu 'Abdullah Muhammad ibn Ahmad ibn Sa'eed al-Tamimi	Chemistry
	923	Iran	Abu al-Abbas al-Fadl ibn Hatim al-Nairizi	Mathematics, Astronomy
930	1030	Iran	Ahmad ibn Muhammad Miskawayh	Medicine, Chemistry
	932	Iran	Abu al-Hasan Ahmed ibn Muhammad al-Tabari	Medicine
936	1013	Spain	Abu al-Qasim Khalaf ibn al-'Abbas al-Zahrawi	Surgery, Medicine
940	997	Iran	Abul Wafa Muhammad ibn Muhammad ibn Yahya ibn Ismail al-Buzjani	Mathematics, Astronomy, Geometry
943	969	Iraq	Abu al-Qasim Muhammad ibn Hawqal	Geography
951	1029	Spain	Abu 'Abd Allah Muhammad ibn Hasan, also known as Ibn al-Kattani	Medicine
960		Iraq	Ibn Wahshiyh	Chemistry, Botany

965	1040	Iraq	Abu 'Ali al-Hasan ibn al-Hasan ibn al-Haytham	Physics, Optics, Mathematics
973	1040	Uzbekistan	Abu Raihan Al-Biruni	Astronomy, Mathematics
976			Ahmad ibn Abi al-Ash'ath	Medicine
	977	Iran	Abul Qasim 'Ubaidullah ibn 'Abdullah ibn Khurdad-bih, al-Istakhri	Geography
	980	Palestine	Muhammad ibn Ahmad Sa'id al-Tamimi	Medicine
	980	Tunisia	Abu Ja'far Ahmad bin Abi Khalid ibn al-Jazzar	Medicine
980	1037	Uzbekistan	Abu 'Ali al-Hussain ibn 'Abd Allah ibn Sina	Medicine, Philosophy, Mathematics
	990	Iran	Abu Mansur al-Hasan ibn Nuh al-Qumri	Medicine
	994	Iran	'Ali ibn 'Abbas al-Majusi	Medicine
997	1075	Spain	'Abd al-Karim ibn Wafid al-Lakhmi	Medicine, Pharmacology
998	1067	Egypt	Abu al-Hasan Ali ibn Ridwan ibn Ali Ja'far al-Misri	Medicine
	1001	Spain	Ibn Tumart al-Maghribi, Abu 'Ali Muhammad ibn Muhammad, al-Audalusi al-Maliki	Astrology, Medicine
1002	1002	Spain	Ibn Samajun, Abu Bakr Hamid	Medicine
950	1009	Egypt	Abu al-Hasan 'Ali abi Sa'id 'Abd al-Rahman ibn Ahmad ibn Yunus al-Sadafi al-Misri, also known as ibn Yunus	Astronomy, Mathematics
997	1074	Spain	Ibn al-Wafid	Medicine
First half of 11 th C	First half of 11 th C	Iraq	Sharaf al-Din 'Ali ibn 'Isa al-Kahhal	Medicine, Ophthalmology
1010	1094	Spain	Abu 'Ubayd 'Abdallah ibn 'Abd al-Aziz ibn Muhammad al-Bakri	Geography
1019			Al-Hasib Alkarji	Mathematics
	1019	Iran	Abu al-Faraj 'Ali ibn al-Hussein	Medicine
1029	1087	Spain	Abu Ishaq Ibrahim ibn Yahya Al-Zarqali	Astronomy
Mid 12 th C	Mid 12 th C		Ibrahim ibn Abi Sa'id ibn Ibrahim al-Maghribi al-'Ala'i	Medicine

	1100	Iraq	Abu 'Ali Yahya ibn 'Isa ibn Jazlah	Medicine
	1141	Iran	Muhammad ibn Yusuf Ilaqi	Medicine
1044	1123	Iran	Ghiyath al-Din Abul Fateh 'Umar ibn Ibrahim al-Khayyam	Mathematics, Poetry
	1066	Iraq	Abu al-Hasan al-Mukhtar ibn 'Abdun ibn Butlan	Medicine
	1068	Iran	Abu al-Qasim 'Abd al-Rahman ibn 'Ali ibn Abi Sadiq	Medicine
1077			Abul Qasim 'Abdul Rahman ibn 'Ali ibn Ahmad ibn Abi Sadiq al-Nisaburi	Medicine
1080	1170	Spain	Abu Hamid al-Gharnati	Geography
1091	1161	Spain	Abu Marwan ibn Zuhr.	Medicine, Surgery
1095			Abu Bakr Muhammad ibn Yahya al-Saigh, also known as Ibn Bajah	Philosophy
1099	1166	Spain	Abu 'Abd Allah Muhammad al-Idrisi	Geography
Early 12 th C	Early 12 th C	Iran	Ahmad ibn Farrukh	Medicine
1105	1185	Spain	Abu Bakr Muhammad ibn 'Abd al-Malik ibn Muhammad ibn Tufail al-Qaisi al-Andalusi, also known as Ibn Tufail	Philosophy, Medicine
1061	1120	Iran	Abu Ismaeel al-Hussain ibn 'Ali ibn Muhammad ibn 'Abdul Samad, also known as al-Tughr'i	Chemistry, Poetry
	1153	Turkey	Abu Nasr 'Adnan ibn Nasr 'Aynzarbi	Medicine
1076	1165	Iraq	Abu al-Hasan Hibat Allah ibn Tilmidh	Calligraphy, Medicine, Poetry, Theology
	1193		Abu Nasr Sa'id ibn Abi al-Khayr al-Masihi ibn 'Isa al-Mutatabbib	Medicine
	1198	Egypt	Ibn Jumay' al-Isra'ili [or, Ibn Jami'], Abu al-Makarim Hibat Allah	Medicine
2nd half of 12 th C	2nd half of 12 th C		Abu al-Qasim Muhammad ibn 'Abd Allah al-Ansari	Alchemist
1126	1198	Spain	Abu al-Walid Muhammad ibn Ahmad ibn Muhammad ibn Rushd	Biology, Medicine, Philosophy, Physics
1135	1204	Spain	Abu 'Imran Musa ibn 'Ubayd Allah ibn Maymun al-Qurtubi	Medicine, Philosophy

	1136	Iran	Jurjani, Isma'il ibn Muhammad al-Husayn	Medicine
	1140	Iraq	Al-Badee Al-Astrulabi	Astronomy, Mathematics
1149	1209	Iran	Abu 'Abd Allah Muhammad ibn 'Umar ibn al-Husayn Fakhr al-Din al-Razi	Theology, Astrology, Medicine
	1155		Abdul-al Rahman al-Khazin	Astronomy
1155	1208		'Abd al-'Aziz ibn 'Abd al-Jabbar al-Sulami	Medicine
1164	1164	Syria	'Abd al-Rahman ibn Nasr ibn 'Abd Allah Shayzari	Medicine
1165	1240	Spain	Muhyi al-Din ibn al-'Arabi	Astrology, Medicine
1163	1231	Iraq	Muwaqqaf al-Din Abu Muhammad ibn Yusuf 'Abd al-Latif al-Baghdadi	Medicine, Geography
1165			Ibn A-Rumiyyah Abul' Abbas	Botany
1173	1243	Syria	Rashid al-Din al-Mansur ibn al-Suri	Botany
1184	1253	Tunisia	Ahmad ibn Yusuf al-Tifashi	Metallurgy, Stones
	1191	Syria	Ibn al-Mutran (or, Ibn Matran), Muwaqqaf al-Din Abu Nasr As'ad ibn Ilyas	Medicine
1197	1248	Spain	Abu Muhammad 'Abd Allah ibn Ahmad Dhia al-Din ibn al-Baytar	Botany, Medicine, Pharmacology
1201	1274	Iran	Abu Jafar Muhammad ibn Muhammad ibn al-Hasan Nasir al-Din al-Tusi	Astronomy, Geometry
1203	1270	Iraq	Ibn Abi Usaybia	Medicine
1204	1292		'Izz al-Din Abu Ishaq Ibrahim ibn Muhammad ibn Tarkhan Suwaydi	Medicine
	1204		Al-Hassan al-Murarakishi	Mathematics, Astronomy, Geography
	1204	Morocco	Nur al-Din ibn Ishaq al-Bitruji	Astronomy
	1206	Iraq	Ibn Ismail ibn al-Razzaz al-Jazari	Engineering
	1213	Iraq	Ibn Hubal, Muhaddhab al-Din 'Ali ibn Ahmad, al-Baghdadi al-Khilati	Medicine
1213	1288	Iraq	Ala al-Din Abu al-Hassan Ali ibn Abi Hazm al-Qarshi al-Dimashqi, also	Anatomy, Medicine
	1221	Afghanistan	Abu Hamid Muhammad 'Ali ibn 'Umar Najib al-Din 'Ali al-Samarqandi	Medicine

	1225	North Africa	Abu al-‘Abbas Ahmad ibn ‘Ali ibn Yusuf al-Buni	Medicine
1233	1286	Syria	Ibn al-Quff, Abu al-Faraj ibn Muwaffaq al-Din Ya‘qub ibn Ishaq	
1236	1311	Iran	Qutb al-Din al-Shirazi	Astronomy, Geography
	1240	Egypt	Ibn Abi al-Bayan, Abu al-Fadl Da‘ud al-Isra‘ili	Medicine
Mid 12 th C	Mid 12 th C	Turkmenistan	‘Abd al-Rahman al-Khazini	Astronomy, Biology, Chemistry, Mathematics
Mid 12 th C	Mid 12 th C	Iran	Muhammad ibn ‘Ali ibn Rustam al-Khurasani, also known as al-Sa‘ati	Engineering
	1248	Egypt	Ibn al-Qifti, ‘Ali ibn Yusuf	Medicine
	1253		Ahmad ibn Yusuf al-Tifashi	Hygiene, Chemistry
	1285	Morocco	Shihab al-Din al-Qarafi	Fiqh, Optics
Mid 13 th C	Mid 13 th C		Abu al-Qasim Ahmad ibn Muhammad al-‘Iraqi al-Simawi	Chemistry
1256	1321	Morocco	Abu al-Abbas Ahmad ibn Muhammad ibn ‘Uthman al-Azdi (also known as Ibn al-Banna)	Medicine, Mathematics
	1251		Qaisar ibn Abu al-Qasim	Engineering, Mathematics
	1258	Egypt	Fath al-Din ibn ‘Uthman ibn Hibat Allah Qaysi	Medicine
1260	1320	Iran	Kamal al-Din Abu al-Hasan Muhammad al-Farisi	Astronomy, Physics
	1262	Morocco	Abu ‘Ali al-Hasan ibn ‘Ali al-Marrakushi	Astronomy, Mathematics
1273	1331	Iraq	Abu Al-fida’ Isma‘il ibn ‘Ali al-Malik al-Mu‘ayyad Imad al-Din (also known as Abu al-Fida)	Astronomy, Geography
1274	1348	Syria	Abu ‘Abd Allah Muhammad ibn Ahmad ibn ‘Uthman al-Dhahabi	Medicine, History, Theology
	1283	Iran	Zakariya’ ibn Muhammad al-Qazwini	Medicine
1290	1290		Amin al-Din Rashid [al-Din] Vatvat	Medicine

Late 13 th C	Late 13 th C		Shams al-Din Muhammad ibn Mahmud Shahrazuri	Medicine
1313	1375	Spain	Ibn al-Khatib, Lisan al-Din	Medicine
	1344		Mahmud ibn Muhammad ibn ‘Umar al-Jaghmini	Medicine
	1348	Egypt	Ibn al-Akfani, Shams al-Din, Muhammad ibn Ibrahim al-Sinjari al-Misri	Ophthalmology, Medicine
Mid 13 th C	Mid 13 th C	Syria	‘Ali ibn ‘Abd al-‘Azim al-Ansari	Medicine
1306			Ibn al-Shater al-Dimashqi	Astronomy, Mathematics
	1327	Syria	Shams al-Din, Muhammad ibn Abi Talib al-Ansari al-Dimashqi	Cosmology, Medicine
1332	1406	Tunisia	Abu Zayd ‘Abd al-Rahman ibn Muhammad ibn Khaldun	Demography, Economy, History, Sociology
1334	1334		Mas‘ud ibn Muhammad Sijzi	Medicine
	1341		Muhammad ibn Aidamer al-Jildaki	Chemistry
1341	1405	Egypt	Muhammad al-Damiri	Zoology
	1342	Iran	al-Jaldaki, ‘Izz al-Din Aydamir ibn ‘Abd Allah	Alchemist
1351			Abu ‘Abbas ibn Tanbugha ibn al-Majdi	Mathematics, Astronomy
	1357		Kazaruni, Sadid al-Din Muhammad ibn Mas‘ud	
	1379		Jamal al-Din Muhammad ibn Muhammad Aqsara‘i	Medicine
1380	1429	Iran	Ghiyaseddin Jamsheed Kashani (also known as al-Kashi)	Astronomy, Mathematics
1394	1449	Uzbekistan	Muhammed Taragai Ulugh Beg	Astronomy, Mathematics
	1403		Zayn al-Din ‘Ali ibn Husayn al-Ansari, known as Hajji Zayn al-‘Attar	Medicine
	1599	Egypt	Shadhili, Sadaqah ibn Ibrahim al-Hanafi al-Misri	Ophthalmology

1410	1453	Egypt	Ibn Shahin al-Zahiri, Ghars al-Din Khalil	Medicine
	1412		Muhammad al-Mahdawi ibn 'Ali ibn Ibrahim al-Sanawbari	Medicine
Mid-14 th C	Mid-14 th C	Iran	Muhammad ibn Mahmud Amuli	Medicine
	1413		'Ali ibn 'Abd Allah ibn Haydur	Medicine
1427	1427		Husayn ibn Muhammad ibn 'Ali Astarabadhi	Medicine
1445	1505	Egypt	Jalal al-Din Suyuti	Biography, Fiqh, History, Sciences
1448	1517	Egypt	al-Qastallani, Ahmad ibn Muhammad ibn Abi Bakr	Medicine, Judiciary
	1454	Turkey	'Abd al-Rahman ibn Muhammad ibn 'Ali ibn Ahmad al-Bistami	Medicine
1474	1474	Iran	Ghiyath al-Din 'Ali ibn Amiran al-Husayni al-Isfahani	Anatomy, Botany, Meteorology, Mineralogy,
1492	1492	Afghanistan	Muhammad ibn Yusuf Harawi	Medicine
1495	1561	Iraq	Abu al-Khayr ibn Muslim al-Din Mustafa Tashköprüzade	Medicine
Mid-15 th C	Mid-15 th C	Iran	Imad al-Din Mahmud ibn Mas'ud Shirazi	Medicine
	1520		M u h a m m a d i b n M u h a m m a d (Qununizade) Qawnuni	Medicine
1525	1585	Egypt	Taqi al-Din Muhammad ibn Ma'ruf al-Shami al-Asadi	Medicine
1546	1546		Sayyid 'Ali Hamdani	Medicine
	1565	Egypt	'Abd al-Wahhab ibn Ahmad Sha'rani	Medicine
Mid-16 th C	Mid-16 th C		Rustam Jurjani	Medicine
	After 1572		Muhammad 'Abd Allah ibn Muhammad ibn Mas'ud al-Dar'i al-Tafjaruti (or Tamakruti)	Hygiene
1592	1592		Husayn ibn Ibrahim ibn Wali ibn Nasr ibn Husayn al-Hanafi	Astrology, Medicine
	1599	Syria	Da'ud ibn 'Umar Antaki	Medicine

1609	1640	Turkey	Hezarfen Ahmet Celebi	Flight, Rocketry
	1609	Iran	Hakim 'Ali ibn Kamal al-Din Muhammad al-Jilani	Medicine
1600	1600		Muhammad Baqir Yazdi	Mathematics
Mid 17 th c	Mid 17 th c		Nur al-Din Muhammad 'Abd Allah ibn Hakim 'Ayn al-Mulk Qurayshi Shirazi	
	1659		Shihab al-Din Ahmad ibn Ahmad ibn Salamah al-Qalyubi	Medicine
	1669	Syria	Ibn Sallum, Salih ibn Nasr	Alchemist, Medicine
1670	1747	Iran	Hakim Muhammad Hashim ibn Hakim Muhammad Hadi Qalandar ibn Muzaffar al-Din 'Alavi Shirazi	Medicine
1689	1778		Ahmad ibn 'Abd al-Mun'im Damanhuri	Medicine
1692	1694	Iran	Qiwam al-Din Muhammad al-Hasani	Poetry on medicine, astronomy, arithmetic, calligraphy
1698	1698		'Abd al-Mu'ti ibn Salim ibn 'Umar al-Shibli al-Simillawi	Fiqh, Medicine
Late 17 th C	Late 17 th C		Muhammad Mu'min ibn Mir Muhammad Zaman Daylami Tunakabuni	Fiqh, Medicine
Before 1709	Before 1709		Sulayman ibn Sulayman Muhammad Karim ibn Muhammad Wali ibn Hajji Himmat ibn 'Is ibn Hasan	Medicine
1750	1799	India	Tipu Sultan	Rocketry
	1777		Muhammad ibn Muhammad, Mufti al-Hanafiyah bi-al-Quds al-Tafilati Jurisprudence,	Medicine
18th C	18th C		Bulus ibn Qustantin al-Malaki Shaburi	Medicine
Mid-18 th C	Mid-18 th C	Egypt	Muhammad Aqkirmani	Medicine
	1805	India	Hakim Muhammad Sharif Khan	Medicine
Before 1826	Before 1826		Iran 'Abd Allah ibn Ahmad ibn Muhammad Asfara'ni	Medicine
1828	1828	Iran	Jalal al-Din Muhammad al-Isfahani	Medicine
End of 19 th C	End of 19 th C		Ahmad ibn Muhammad Salawi	Medicine

Decline in Science and Technology

When Islam was being applied as an ideology, with its own political, economic, social, educational and judicial system, Muslims and non-Muslims in the Islamic State enjoyed peace and security, and an environment was created that allowed unhindered scientific discovery. The Islamic State provided finance and support for development of science and technology; it established colleges, universities, research centers and brought together the best minds. This provided the spark that led to the remarkable discoveries and inventions. Thus, development of science and technology was encouraged through state policy and the Muslims rapidly became leaders in many fields of science and technology as a result.

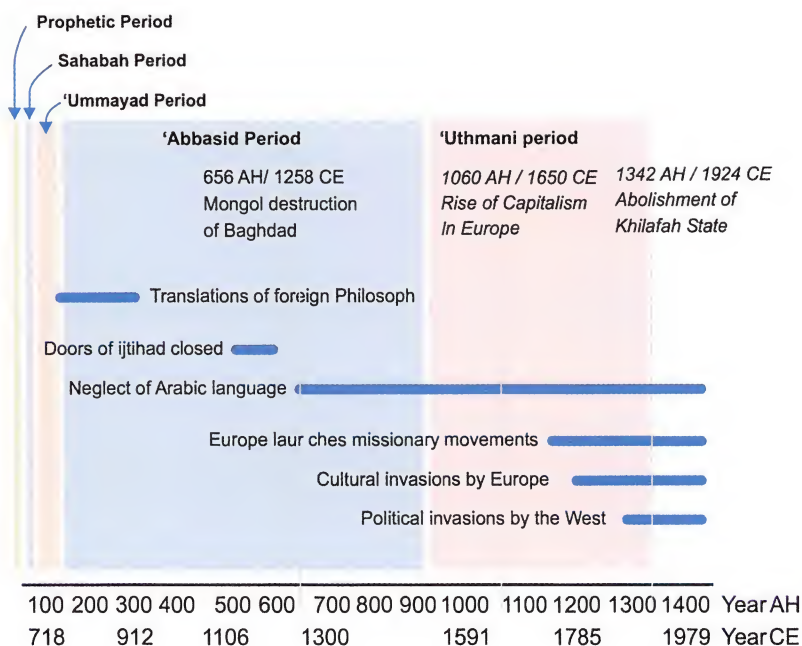
The decline of science and technology in the Muslim world came about as a result of decline in adherence to Islam as an ideology. This ideological decline can be attributed to:

- Infusion of philosophical ideas from Greek, Persian and Indian civilizations
- Abandoned of *ijtihad*²¹
- Neglect of study and understanding of Arabic language.
- Missionary, cultural and political invasions of the West

Amongst the books translated into Arabic from Greeks, Persians and Indians were the books on philosophies. Some of the ideas of these foreign philosophies took root amongst the Muslim scholars and this caused much confusion in their thinking. These ideas included discussion of whether man is compelled to act or he has free will, the knowledge and attributes of God, spirituality and the dichotomy between the soul and the body. The net result was that efforts were made to reconcile Islam with these philosophies despite complete contradictions between them, thus wrong interpretations and explanations were given.

In the 11th Century CE, the doors of *ijtihad* were closed in the Islamic State. Reasons vary but widespread opinion is that the scholars deemed that all the essential questions have been thoroughly discussed and

21. A process to extract ruling for new problems based on the sources of Islam, the primary sources being the Qur'an and the Sunnah of Prophet Muhammad (ﷺ).



settled, and there would be no new situations where *ijtihad* will be required. Another reason cited is that this period saw lots of turmoil, with Crusades taking place and Mongols knocking on the doors of the State, and it was felt necessary to stop internal discussions and debates. Whatever the reasons, the abandonment of *ijtihad* stifled thinking and reduced Islamic nation's ability to extract rules to solve new problems. The effect of this could be felt even to the last days of the 'Uthmani rule, where fatwa's²² were given against using the telephone, citing that it was linked to the whispers of *Shaytan* (Satan), and printing of the Qur'an was forbidden. Incorrect *ijtihad*, or no *ijtihad*, led Muslims to doubt Islam as they could not see how Islam will solve their practical problems. This led to calls for reforming Islam, thus contributing further towards the ideological decline.

After the destruction of Baghdad in 1258 CE by Mongols, the center of Power of the Islamic State shifted to Egypt. However, the key control of the State was in the hands of Mamluks, who were non-Arab in origin. Under their authority, the Arabic language was ignored both in

22. Fatwa is a ruling on Islamic law issued by an Islamic scholar.

understanding and carrying Islam. The neglect of the Arabic language continued under the ‘Uthmani rulers, who took over from the Mamluks in 1517 CE. They too, like the Mamluks, concentrated their efforts on military conquests and neglected the Arabic language despite the fact that it is essential in order to understand Islam and one of the conditions necessary in order to perform *ijtihad*. The neglect of the Arabic language contributed towards the decline in intellectual and legislative aspect of Islam.

The last 300 years also witnessed many campaigns by the West to infiltrate the Islamic State in order to weaken it from within. Military campaigns were initially ruled out as they never proved effective against the Muslims, so they resorted to subtle means. Thus missionaries were sent, beginning in the 17th century CE, to create strife amongst the Muslims by sowing seeds of nationalism. These campaigns eventually succeeded to give away to the next phase of political invasions during the 19th century CE, where many parts of Islamic lands were directly occupied. Once the dismantlement of the State was complete in 1924 CE, the West continued with cultural invasion where the secular Western way of Life has been pushed on the Muslims.

The above mentioned factors all contributed towards the ideological decline, which blurred the vision of the people as the objective of their existence becomes unclear, their priorities of life changed and they faced internal upheavals and conflicts. In fact, ideological decline led to weakness of all institutions of the state initially, but this unchecked decline ultimately led to the destruction of the nation.

The results of the factors of decline only became visible towards the end of ‘Uthmani rule when Capitalism emerged in Europe. The rulers were unable to crystallize the nature of the problem facing the nation, because they too were affected by the decline, and thus their incomprehensibility led to the further problems. The Muslims were faced with all sorts of problems internally and externally with the threat from Europe and Russia. Science and technology was amongst the areas directly impacted as the priorities of the State changed towards survival, funding for research and development declined as financial problem became acute and political instability rendered long terms plans futile as nationalism began to take root amongst the Muslims.

Reviving the development of Science and Technology

Can the Muslim world revive its past glory of leadership in science and technology? The answer is yes. The only way Muslims can take this leadership is to go back to what gave them the leadership in the first place. This is the comprehensive adherence to Islam as an ideology, i.e. full acceptance of the Islamic belief and complete implementation of all systems of Islam, as this will create the correct framework for development. Furthermore, the vast intellectual strength and material resources in the Muslim world can only be utilized effectively if the Muslims are united under a single system, as was the case in the past. This unification of Muslims into a single entity is an essential element for success in the advancement of science and technology.

No nation can progress, scientifically or otherwise, if it does not adopt an ideology, and the Muslims are no exception to this rule. The West adopted Capitalism and progress was made in many areas of life as a result. The East was forced to adopt Communism and it also achieved a certain amount of material progress, especially in science and technology. The Muslims have Islam as an ideology and it is this that will provide the basis of progress. Islam provided ideal environment for scientific discovery in the past, and it can do the same again.

In order to succeed, the Muslims have to create an environment for scientific study and research like the one that existed in the past, with a clear vision and strategy, driven from the State apparatus. Proper resources need to be allocated to colleges, universities and research centers. Solving technical problems, improving efficiency of industrial processes, finding cures for diseases and enhancing material life as much as possible should be amongst the objectives in the policy for science and technology. Ideas turned into practical applications to improve the lives of people must be encouraged.

Conclusion

An objective observer will notice that science stagnated under the Christian Church in Europe because man had tampered with the original revelation, and the Bible was not meant as the everlasting revelation, but rather for the people of that time. It therefore became impossible to reconcile Christianity with reality. However, science bloomed under Islam as there is no contradiction between science and Islam. Thus, the Muslim world enjoyed its golden period when Europe was steeped in the Dark Ages. Since Islam was kept in its original form, it continued to be applicable for every time and place.

Very little is revealed about the glorious history of Islam, in particular, not much is mentioned about 1000 years of rich scientific heritage of the Muslims, which formed bridge between the ancient Greek, Persian and Indian civilizations with the modern age. Europe inherited much of the scientific heritage of the Muslims when the Islamic influence declined and used that as a foundation of its own scientific revolution.

The Muslims were true pioneers, they established various disciplines of science, they named the stars, and they traveled throughout the world and produced some of the finest thinkers of all time. Household words like chemistry, algebra, aorta, pancreas, camera, sugar, syrup, zero, alkali, cotton, coffee and earth are a living testimony of the everlasting Islamic scientific legacy.

People from different nations and cultures were molded by Islam into a society in which the life, honor, and property of every citizen, Muslim and non-Muslim, was secure. Furthermore, Islam broke the shackles of ignorance that had engulfed humanity and provided a system in which Muslims and non-Muslims excelled, among other things, in science and technology.

Appendix

Topical lists of European/Latin words with Arabic origins

Some of the popular words used in the field of science have their roots in Arabic.

Names of Stars

English/Latin Name	Arabic Name
Achernar	Akhir al-Nahr
Acrab	Aqrab (Scorpion)
Aega	Nasr al-Waqi
Aldebaran	Ad-Dabaran
Altair	Nasr al-Tair
Daneb	Dhanab al-Dujajah
Denebola	Dhanab al-Asad
Fomal Haut	Famm al-Hut
Phurked	Farqad (calf)

Mathematical Vocabulary

English/Latin Name	Arabic Name
Algebra	Al-Jabr
Algorism, Algorithm	Al-Khwarizmi
Atlas	Atlas
Average	Awariya
Azimuth	Al-sumut
Cipher, Zero	Sifr
Nadir	Nadir, Nazir
Zenith	Cenit

Anatomical Terms

English/Latin Name	Arabic Name
Aorta	Avarta
Basilie	Baslik
Cephallie	Kifal
Colon	Colon
Corn	Corn
Cornea	Cornea
Diaphragm	Dayafergma
Epidemis	Aghadidus

Menniges	Mennigies
Mesentry	Masarike
Pancreas	Bankras
Peritoneum	Baratene
Sephenous	Safan
Trochanter	Tracanter

Medical Terms

English/Latin Name	Arabic Name
Alcanfor, Camphor	Kafur
Alchemy, Chemistry	Al-kimiya
Alcohol	Al-khul
Anima	Kitab al-Nafs
Antimonio, Antimony, Antimun	Antimun, Ithmid
Benzene	Luban-Jawi
Colliget	Al-Kullyat
Elixir	Al-Aksir
Sufficientia	Kitab al-Shifa
Zircon	Azraq

Names in Chemistry

English/Latin Name	Arabic Name
Adobe	Al-Tub
Alcove	Al-Qubba
Alembic	Alembic
Alkali	Alkali
Aludel	Aludel
Alum	Alum
Amber	Anbar
Arsenal	Dar al-Sina'ah
Artichoke	Al-Kharshuf
Athomor	Athomor
Azylum	Azylum

Other Frequently Used Words

English/Latin Name	Arabic Name
Admiral	Amir al-Bahr

Almanac	Al-Manakh
Amber	Anbar
Arsenal	Dar al-Sina'ah
Artichoke	Al-Kharshuf
Assassin	Hashashin
Athomor	Athomor
Azymum	Azymum
Banana	Banan
Cable	Habl
Calibre	Qalaba
Camel	Jamel
Camera	Qamaara
Canon	Qanun
English/Latin Name	Arabic Name
Checkmate	Shah Mat
Cinnabar	Cinnabar
Coffee	Qahwa
Cotton	Qutun
Earth	Ardh, Earz
Gibberish	Jabir ibn Hayyan
Giraffe	Zurafa
Hazard	Al-Zahr
Jasmine	Yasmin
Jumper	Jubbah
Lemon	Limun
Lute	Al-'ud
Magazine	Makhazin
Mattress	Matra
Monsoon	Mawsim
Musk	Musk
Orange	Naranj
Rice	Ruzz
Safari	Safara
Safron	Zafaran
Sugar	Sukkar
Syrup	Shurb, Sharab
Tutia	Tutia
Usefur	Usefur
Ziniar	Ziniar

NOTE:

The readers are welcome to use historical facts, ideas and concepts in this book, without restriction, to promote the objectives of this book.

Also, as some of the works quoted here are not available in original format, only references to them are found in books by later generations of scientists, it is possible that discrepancies in names, dates and places may occur. The author will appreciate if any corrections can be sent to him at masa-tech@hotmail.com.